

# RESEARCH BRANCH REPORT

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❁ 1979 ❁

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# RAPPORT DE LA DIRECTION DE LA RECHERCHE

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Agriculture  
Canada



Research  
Branch Report

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1979

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Rapport  
de la Direction  
de la recherche

RESEARCH BRANCH  
DIRECTION DE LA RECHERCHE

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AGRICULTURE CANADA

Copies of this publication are available from

Research Program Service  
Research Branch  
Agriculture Canada  
Ottawa, Ont.  
K1A 0C6

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publication à la

Service des programmes de recherche  
Direction de la recherche  
Agriculture Canada  
Ottawa (Ont.)  
K1A 0C6

©Minister of Supply and Services Canada 1980  
Cat. No. A51-1/1979 ISBN 0-662-50946-3  
Printed 1980

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N° de cat. A51-1/1979 ISBN 0-662-50946-3  
Impression 1980

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Dr. E. J. LeRoux



Dr. J. W. Morrison



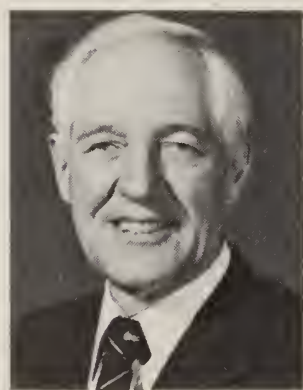
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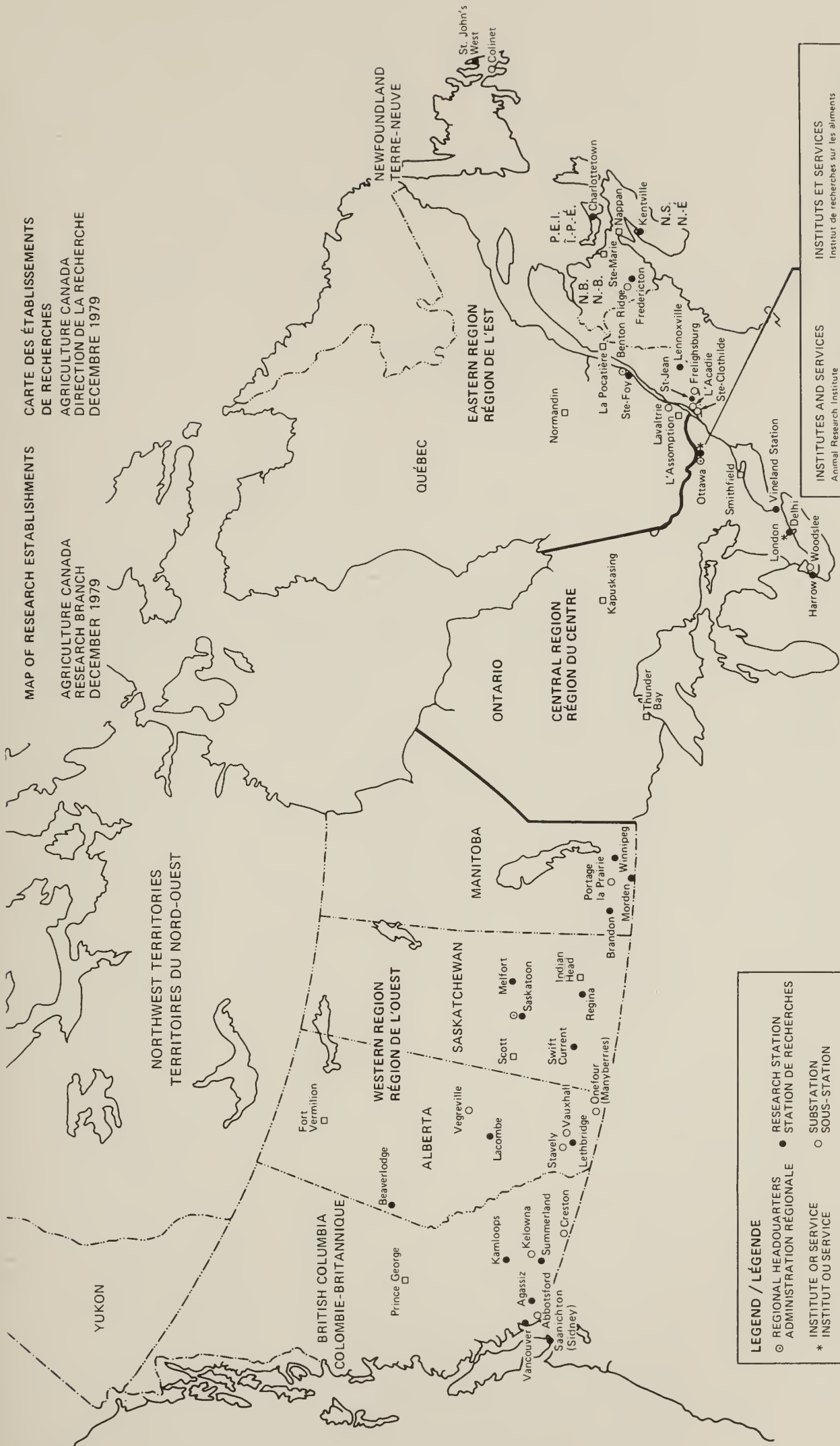


MAP OF RESEARCH ESTABLISHMENTS  
DE RECHERCHES

AGRICULTURE CANADA  
RESEARCH BRANCH  
DECEMBER 1979

MAP OF RESEARCH ESTABLISHMENTS  
DE RECHERCHES

AGRICULTURE CANADA  
DIRECTION DE LA RECHERCHE  
DECEMBRE 1979



**LEGEND / LÉGENDE**

- REGIONAL HEADQUARTERS / ADMINISTRATION RÉGIONALE
- RESEARCH STATION / STATION DE RECHERCHES
- \* INSTITUTE OR SERVICE / INSTITUT OU SERVICE
- EXPERIMENTAL FARM / FERME EXPÉRIMENTALE
- SUBSTATION / SOUS-STATION

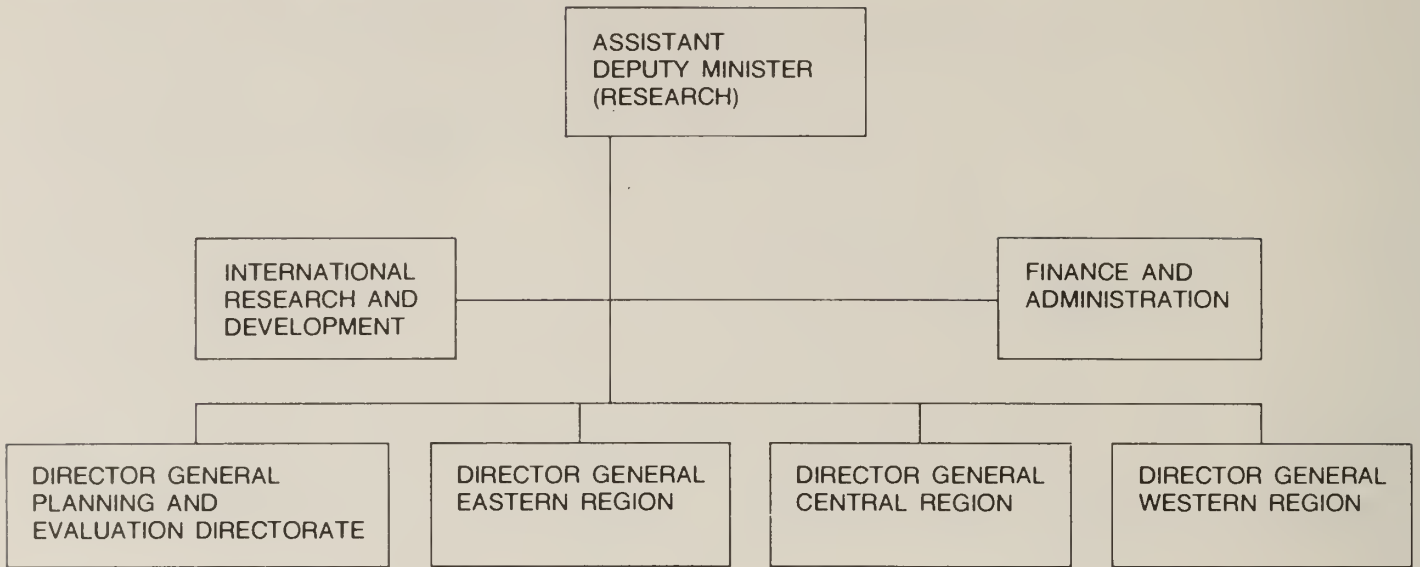
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**INSTITUTES AND SERVICES**

**INSTITUTS ET SERVICES**

- Animal Research Institute / Institut de recherches sur les animaux
- Biosystematics Research Institute / Institut de recherches biosystématiques
- Chemistry and Biology Research Institute / Institut de recherches chimiques et biologiques
- Engineering and Statistical Research Institute / Institut de recherches techniques et statistiques
- Food Research Institute / Institut de recherches sur les terres
- Land Resource Research Institute / Institut de recherches zootechniques
- Research Program Service / Service des programmes de recherches

**ORGANIZATION OF THE RESEARCH BRANCH**



Research Coordinators

Analysts

Advisers

Research Stations

St John's West, Nfld  
 Colinet, Nfld  
 Charlottetown, P E I  
 Kentville, N S  
 Nappan, N S  
 Fredericton, N B  
 Benton Ridge, N B  
 Sainte-Marie, N B  
 Lennoxville, Qué  
 Sainte-Foy, Qué  
 La Pocatière, Qué  
 Normandin, Qué  
 Saint-Jean, Qué  
 Frelighsburg, Qué  
 L'Acadie, Qué  
 L'Assomption, Qué  
 Lavaltrie, Qué  
 Sainte-Clothilde, Qué

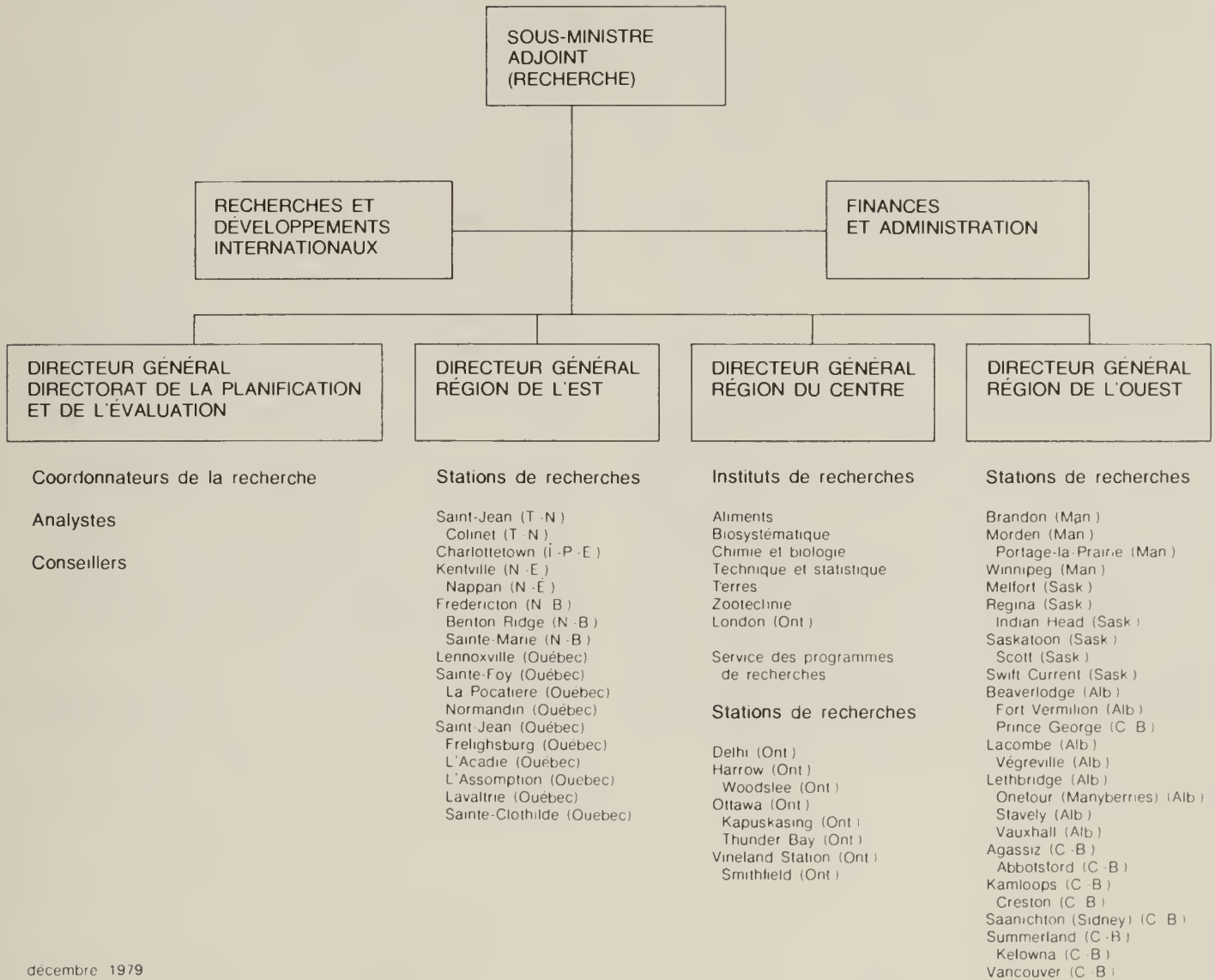
Research Institutes

Animal  
 Biosystematics  
 Chemistry and Biology  
 Engineering and Statistical  
 Food  
 Land Resource  
 London  
 Research Program Service  
 Research Stations  
 Delhi, Ont  
 Harrow, Ont  
 Woodslee, Ont  
 Ottawa, Ont  
 Kapuskasing, Ont  
 Thunder Bay, Ont  
 Vineland Station, Ont  
 Smithfield, Ont

Research Stations

Brandon, Man  
 Morden, Man  
 Portage la Prairie, Man  
 Winnipeg, Man  
 Melfort, Sask  
 Regina, Sask  
 Indian Head, Sask  
 Saskatoon, Sask  
 Scott, Sask  
 Swift Current, Sask  
 Beaverlodge, Alta  
 Fort Vermilion, Alta  
 Prince George, B C  
 Lacombe, Alta  
 Végreville, Alta  
 Lethbridge, Alta  
 Onefour (Manyberries), Alta  
 Stavely, Alta  
 Vauxhall, Alta  
 Agassiz, B C  
 Abbotsford, B C  
 Kamloops, B C  
 Creston, B C  
 Saanichton (Sidney), B C  
 Summerland, B C  
 Kelowna, B C  
 Vancouver, B C

## ORGANISATION DE LA DIRECTION DE LA RECHERCHE



## FOREWORD

The Research Branch of Agriculture Canada conducts about one-half of the agricultural research and development in Canada. It also cooperates with universities and industry by supporting research that augments the Branch's goals and objectives. The budget for 1979 was \$126 million, of which \$5 million was spent on contracted research. In 1979 the Branch staffed 3673 person-years, of which 900 were professional positions.

Branch Headquarters are located at the Central Experimental Farm, Ottawa. In 1978 the Branch was reorganized into three regions with headquarters at Saskatoon, Sask.; Ottawa, Ont.; and Quebec City, Que. This Report is presented by region, with each director general describing his organizational structure and highlighting achievements for the year. The research establishments then give details of their work in separate chapters, for which reprints are available.

The Branch conducts basic and applied research on soils, plants, animals, pests including diseases and weeds, engineering and energy, and food. There is close cooperation with other branches in the Department, with other federal agencies, and with universities, provincial departments of agriculture, the agricultural industry, and farm organizations.

In Canada there is a unique system for coordinating agricultural research and services, called the Canadian Agricultural Services Coordinating Committee (CASCC).

This organization reviews governmental and institutional services affecting the general welfare of Canadian agriculture. Its members include provincial deputy ministers of agriculture, deans of agricultural colleges and colleges of veterinary medicine, and representatives from the private sector. The Chairman is the Deputy Minister of Agriculture Canada. The research arm of CASCC is the Canadian Agricultural Research Council, which advises the parent committee on the state and needs of agricultural research and development. Despite resource constraints, the Research Branch has maintained a high quality of output and has contributed significantly to the departmental aims and the government's policies in support of the Canadian agricultural industry.

The Branch also strongly supports and cooperates in research at the international level. This support is partly provided through the Canadian International Development Agency and the International Development Research Centre. The Branch also has direct relations with the Organization for Economic Cooperation and Development (OECD) and the Food and Agriculture Organization (FAO). Through annual tripartite meetings with leaders of agricultural research in the USA and the UK, effective exchanges are occurring and cooperation is being maintained.

E. J. LeRoux

## AVANT-PROPOS

La Direction de la recherche d'Agriculture Canada réalise environ la moitié des travaux de recherche et de développement agricoles effectués au Canada. Elle coopère également avec les universités et l'industrie en appuyant financièrement les recherches qui viennent compléter ses buts et ses objectifs. En 1979, son budget s'élevait à 126 millions de dollars dont 5 millions pour la recherche contractuelle et son effectif était de 3,673 années-personnes dont 900 chercheurs.

La Direction loge son administration centrale à la Ferme expérimentale centrale d'Ottawa. En 1978, elle était restructurée en trois régions, avec des centres administratifs à Saskatoon (Sask.), Ottawa (Ont.) et Québec (Québec). Ce rapport est présenté par région. Chaque directeur général décrit l'organisation dont il est responsable et ses principales réalisations durant l'année écoulée. Chaque établissement de recherches présente ensuite ses travaux dans des chapitres dont on peut obtenir des tirés à part.

La Direction fait de la recherche fondamentale et appliquée sur les sols, les plantes, les animaux, les ravageurs, les pathogènes, les mauvaises herbes, le génie rural et l'exploitation de l'énergie, ainsi que l'alimentation. Elle travaille en étroite collaboration avec d'autres Directions du Ministère, d'autres organismes fédéraux ainsi que les universités, les ministères provinciaux de l'agriculture, l'industrie agricole et les groupements d'agriculteurs.

Le Canada s'est doté d'un mécanisme particulier de coordination de la recherche et des services agricoles. Il s'agit du Comité

canadien de coordination des services agricoles (CCCSA) dont le rôle est de superviser les services gouvernementaux et institutionnels touchant l'état général de l'agriculture canadienne. Il est composé des sous-ministres provinciaux de l'agriculture, des doyens des facultés d'agriculture et de médecine vétérinaire ainsi que des représentants du secteur privé. Son président est le sous-ministre fédéral de l'agriculture. La fonction «recherche» est confiée au Conseil de la recherche agricole du Canada qui conseille le CCCSA sur l'état et les besoins de la recherche et du développement agricoles. Malgré le resserrement de ses ressources, la Direction a réussi à conserver un rendement de haut calibre et à épauler le Ministère et le gouvernement dans la réalisation des politiques axées sur la prospérité de l'industrie agricole canadienne.

En outre, la Direction encourage la recherche au niveau international et y coopère énergiquement, entre autres par l'entremise de l'Agence canadienne de développement international et le Centre de recherche pour le développement international. Elle est également en contact direct avec l'Organisation de coopération et de développement économiques (OCDE) et l'Organisation des Nations-Unies pour l'alimentation et l'agriculture (*F.A.O.*). Les réunions annuelles tripartites tenues avec les chefs de file de la recherche agricole aux États-Unis et au Royaume-Uni sont l'occasion d'établir des échanges fructueux et de renouer des liens de coopération.

E.J. LeRoux



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 EASTERN REGION   
RÉGION DE L'EST

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Dr. J. J. Cartier



Dr. C. Aubé



Mr. J. R. Frappier



**EXECUTIVE OF THE EASTERN REGION**  
***L'EXÉCUTIF DE LA RÉGION DE L'EST***

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***Spécialiste en programmes***

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***Chef, Finances et administration***

J. R. FRAPPIER, B.A.

## PRÉFACE

La région de l'Est, dont le bureau régional est à Québec, dessert les provinces de Terre-Neuve, de l'Île-du-Prince-Édouard, de la Nouvelle-Écosse, du Nouveau-Brunswick et de Québec. La région de l'Est comprend sept stations, cinq fermes expérimentales et six sous-stations. La ferme expérimentale Sénateur Hervé J. Michaud, située à Sainte-Marie dans le comté de Kent (N.-B.), est la plus récente. Elle porte le nom de feu l'Honorable Michaud, l'un de ceux qui ont le plus travaillé à la relance de l'agriculture dans ce coin de l'Acadie. La région de l'Est dispose d'environ 600 employés, dont 160 chercheurs, pour mener à bien ses projets de recherches. Elle fait aussi appel à l'entreprise privée et aux universités, auxquelles elle octroie des contrats de recherches et des subventions.

L'agriculture de la région repose sur les cultures fourragères plus précisément la fléole, la luzerne et le trèfle. En outre, l'on valorise de plus en plus les céréales, surtout l'avoine, le blé et l'orge par le développement de meilleurs cultivars. Un premier succès a été obtenu avec l'avoine Alma et les travaux en cours sont prometteurs pour ce qui est de la fléole et de la luzerne. Des progrès notables ont été réalisés au niveau de l'inoculation de la luzerne et de la survie de ces plantes à l'hiver. La station de Fredericton travaille sur la production et l'entreposage.

Le sud-ouest du Québec est pour sa part bien pourvu en sols organiques. C'est d'ailleurs le principal centre de production légumière de la province. Les chercheurs de Saint-Jean espèrent réduire le taux d'affaissement des sols fertiles. Ils s'intéressent aussi à la mise en valeur des sols minéraux, aux résidus, ainsi qu'au contrôle des insectes et des mauvaises herbes. Des recherches sur les légumes sont effectuées dans presque toutes les stations de l'Est.

Les recherches fruitières portent presque exclusivement sur la pomme, la fraise, la framboise et le bleuet. Les perspectives d'avenir sont assez intéressantes pour ces cultures qui ont fait la renommée de certaines régions, notamment la Vallée-d'Annapolis et le Lac-Saint-Jean. Quelques projets touchent la poire et la prune.

Le tabac, le pois sec, le soja et même le rhododendron font l'objet de recherches dans certaines stations.

Les problèmes que rencontrent les éleveurs sont très complexes. Les conditions du marché influent beaucoup plus sur les productions animales que sur les découvertes scientifiques. Malgré tout, les recherches zootechniques sont appelées à se développer davantage dans l'avenir. Aujourd'hui, elles veulent satisfaire plus adéquatement aux exigences alimentaires des animaux, mettre au point des rations économiques et explorer les mystères de l'hérédité. Le développement d'une lignée de brebis capables d'agneler en tout temps de l'année devrait être un stimulant pour l'élevage ovin. Une utilisation plus rationnelle du veau laitier pourrait mettre à profit ce produit de l'industrie laitière. L'augmentation du nombre de porcelets sevrés annuellement par la truie et l'amélioration de leur croissance va permettre au secteur porcin de progresser encore.

Isolée du continent, l'Île de Terre-Neuve a deux projets agricoles importants: contrôler le nématode doré et mettre en valeur par les cultures fourragères et légumières des milliers d'hectares marécageux.

Différents changements ont eu lieu au point de vue administratif durant l'année 1979. Tout d'abord, M. G.M. Weaver, Ph.D., a été nommé directeur de la station à Kentville (N.-É.), M. C.S. Bernard, Ph.D., est devenu directeur à la station de recherches à Fredericton (N.-B.), M. Y. Martel, Ph.D., a été nommé directeur de la station de recherches à Lennoxville (Québec) et M. F.W. Calder a été nommé officier en charge à la ferme expérimentale à Nappan.

On peut obtenir de plus amples renseignements au sujet de nos programmes, en écrivant aux établissements de recherches intéressés ou en s'adressant à l'Administration centrale de la région de l'Est, Direction de la recherche, Agriculture Canada, 3194, chemin Sainte-Foy, Sainte-Foy (Québec), G1X 1R4.

J.J. Cartier

## PREFACE

The Eastern Region, whose regional office is in Quebec City, covers the provinces of Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, and Quebec. The Region comprises seven stations, five experimental farms, and six substations. The most recent of its research establishments is the Senator Hervé J. Michaud Experimental Farm at Sainte-Marie in Kent County, New Brunswick. It is named in honor of Senator Michaud, a man who was dedicated to the advancement of agriculture in this corner of Acadia. The Eastern Region employs 600 people, 160 of them professionals, to carry out its research projects. It also relies on private industry and the universities, to which it awards research contracts and grants.

The Region's agricultural activity is based on forage crops, in particular timothy, alfalfa, and clover. Increasing stimulus is also being given to production of cereals, notably oats, wheat, and barley, through the development of better cultivars. Success has already been achieved with Alma oats, and the work being done with timothy and alfalfa looks promising. Significant progress has been made in alfalfa inoculation and the winter survival of these plants. The Research Station at Fredericton is working on production and storage.

Southwestern Quebec is richly endowed with organic soils and is the province's chief vegetable-growing area. Researchers at Saint-Jean are hoping to reduce the rate of subsidence of the fertile soils. They are also working on making mineral soils productive, and are conducting research on residues and on insect and weed control. Research on vegetables is being done at almost all the eastern stations.

Research on fruit crops is centered on apples, strawberries, raspberries, and blueberries. These crops show good prospects and have made a name for certain regions, notably the Annapolis Valley and Lake Saint-Jean. Some research is also being done on the pear and the plum.

Tobacco, dry peas, soybeans, and even rhododendrons are also studied at some stations.

The problems faced by livestock farmers are many and varied. Market conditions have a much greater influence on animal production than do scientific discoveries. Nevertheless, research in animal science will continue to produce benefits in future. Present research is aimed at better satisfying livestock feed requirements, developing economical rations, and exploring the intricacies of heredity. The development of a line of ewes capable of lambing at any time of year should provide a stimulus to sheep breeders. A more rational use of the dairy calf could increase profits for the dairy industry. Increasing the number of pigs weaned by each sow in a year and improving their growth is hoped to further stimulate the swine sector.

Isolated from the mainland, Newfoundland has two major agricultural projects: controlling the golden nematode, and reclaiming thousands of hectares of swampland through forage and vegetable cropping.

There were a number of administrative changes in 1979. Dr. G. M. Weaver was named Director of the Research Station at Kentville in Nova Scotia; Dr. C. S. Bernard became Director of the Research Station at Fredericton in New Brunswick; Dr. Y. Martel was appointed Director of the Research Station at Lennoxville in Quebec; and Mr. F. W. Calder was named Officer in Charge of the Nappan Experimental Farm in Nova Scotia.

Further information about our programs may be obtained by writing to the research establishments concerned or by addressing inquiries to Eastern Region Headquarters, Research Branch, Agriculture Canada, 3194 Sainte-Foy Avenue, Sainte-Foy, Que. G1X 1R4.

J. J. Cartier



# Research Station

## St. John's West, Newfoundland

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#### Horticulture

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#### Plant Breeding and Pathology

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M. C. HAMPSON, B.Sc., M.Sc., Ph.D. Plant diseases

#### Agronomy

A. F. RAYMENT, B.Sc., M.Sc. Soil fertility and drainage

## INTRODUCTION

The Research Station at St. John's West is responsible for regional research on the reclamation and agricultural use of peat soils, potato breeding for resistance to wart disease, and golden nematode control. The research program also includes research on insect control, plant diseases and nutrition, suitable vegetable varieties, and the design and adaptation of mechanical equipment for cultivating, fertilizing, seeding, and harvesting crops grown on peat soils.

Previous reports and reprints of publications can be obtained from: Research Station, Research Branch, Agriculture Canada, P.O. Box 7098, St. John's West, Nfld. A1E 3Y3.

H. W. R. Chancey  
Director

## ENTOMOLOGY

### Cabbage maggot

In 2nd yr field tests at St. John's and Wooddale to determine if cabbage root maggots were developing resistance to organophosphate insecticides, results showed that field populations of the maggot were resistant to Dasanit (fensulfothion) at Wooddale. This resistance was less evident at St. John's where partial maggot control was obtained. The carbamate insecticide Furadan (carbofuran) provided satisfactory control of the maggot at both localities.

Experiments to evaluate pyrethroid insecticide control of cabbage root maggot on late cabbage at St. John's were inconclusive because of a light infestation of the maggot. Twelve treatments replicated four times in a random block design were set out on 21 June, but mortality in the control plots was only 5% and there was no significant difference in marketable yields between treated and untreated plots.

### Lepidopterous caterpillars

Field trials with early cabbage and dwarf Essex rape to determine effectiveness of pyrethroid insecticides (Ambush, Ripcord, Belmark, Pounce, Thuricide, Thiodan, and PP383) in controlling leaf-eating caterpillars showed that all significantly reduced populations of the imported cabbageworm, *Pieris rapae* (L.). Infestations of purplebacked cabbageworms, *Evergestis pallidata* (Hufn.), and diamondback moth larvae, *Plutella xylostella* (L.), were very light in both early cabbage and rape plots so that the effectiveness of the treatments could not be determined with certainty. All treatments

avored an increase in aphid populations by controlling predatory syrphid larvae.

### Leaf tier

Eighteen insecticide treatments, including Ambush, Belmark, Ripcord, PP383, Pounce 320, and Guthion, were tested for control of blueberry leaf tier, *Argyrotoza curvalana* (Kft.), at Brigus Junction. All pyrethroid insecticides reduced larval populations but the medium and high rates were less effective in some cases than was the low rate. A decline of larval populations in control plots similar to that in treated plots made evaluation of the treatments difficult. The experimental design, with insufficient control plots, may partly account for larval decline in the four control plots, although infestation by the leaf tier was lighter this year than in 1978.

### Sheep blow fly

Ectiban (permethrin) at 50 g/L was further tested at St. John's for control of blow fly, *Phaenicia sericata* (Mg.), in sheep. The insecticide was used in single dip treatments at 0.05% and 0.1% solutions and all test animals were submerged for 60 s. Complete control of sheep blow fly was obtained through the entire test period with Ectiban in a 0.1% dip solution.

## PLANT BREEDING AND PATHOLOGY

### Potato breeding for resistance to wart and golden nematode

The wart resistant selection N433-21, a late maturing, blue-skinned, heavy-yielding cultivar, was named Blue Mac and licensed for

commercial production in early 1979. Blue Mac tubers have a high dry matter content, consistently outyield Arran Victory, and have been favorably received by farmers.

Replicated trials of four blue-skinned, eleven white-skinned, and seven red-skinned selections with commercial potential were made at St. John's, using Arran Victory, Kennebec, and Chieftain as controls. None of the blue-skinned selections were equal in specific gravity to Arran Victory, but three had double the yield. All selections remained wart free when tested at Avondale, but none were nematode resistant. Red-skinned selections were not as attractive in appearance as Chieftain but all had higher specific gravity. Kennebec significantly outyielded all selections in marketable yields.

### **Infectivity and germination in potato wart disease**

*Sprout length.* In an analysis of potato sprout length versus wart pathogenesis, infection resulted when sprouts were inoculated at the shoot rather than the base and short shoots escaped infection. When sprout lengths were compared through several monthly irrigation cycles in bench soil, 2 mm sprouts were least infected, 8 mm sprouts were most infected, and 4 mm sprouts were somewhat less infected.

*Sprout exudate.* Samples of potato sprout exudate were freeze-dried and analyzed in an amino acid analyzer. Substances identified, listed in descending order of quantity, were: proline, asparagine,  $\gamma$ -aminobutyric acid, aspartic acid, glutamine, alanine, valine, glutamic acid, serine, ammonia, leucine, phenylalanine, arginine, L-isoleucine, glycine, lysine, threonine, tyrosine, tryptophan, methionine, histidine, ornithine, ethanolamine,  $\frac{1}{2}$ -cystine, traces of  $\alpha$ -amino adipic acid and citrulline, plus four unknowns. Proline is a most unusual component as it generally appears ranked 7 to 15 in tuber flesh analysis.

*Sporangial morphology.* Wart sporangia were killed, fixed, and examined with scanning and transmission electron microscopy. The topography of sporangia revealed a wall of irregular plates fused to form conspicuous ridges, conspicuous pores, and pitted areas. The pores did not traverse the whole width of the wall. In section, the endospore wall evaginated at places into the sporangial lumen, forming knob-like processes. Chitinase

treatment after 18 h failed to alter wall components and structure.

### **Breeding clubroot-resistant rutabagas**

The cultivar Fortune, bred from a cross of York and Wilhelmsburger, was licensed in 1979. It was included in trials by the Royal Horticultural Society, Wisley, England, and received an Award of Merit.

Crosses of the New Zealand summer turnip York and the Norwegian variety Gry produced roots segregating for flesh and skin color. In addition to green and purple-skinned roots, bronze and pink-skinned roots were also obtained. Clubroot-resistant selections were made from Gry  $\times$  RST and the 1977 and 1978 polycrosses, and two turnip varieties, Roots and Golden Ball, remained clubroot free, as did the German rutabaga Niko.

## **PLANT SCIENCE**

### **Field crops**

*Cabbage.* Results with the cultivar Houston Evergreen grown on mineral soil showed that early seeding, together with preplant N at 224 kg/ha and side-dressed N at 112 kg/ha, was essential for high yields. Increasing the N level by side-dressing increased yields by 20.5%, 35.0%, and 11%, respectively, for the 24 May, 30 May, and 13 June seedings. Early planting was not necessary to obtain high yields with Houston Evergreen transplants under the same N treatments.

*Carrots.* Experiments on virgin peat with the cultivar Spartan Fancy were conducted to evaluate Cu and Mo requirements of carrots at the Colinet bog. Three rates of Cu, 3, 9, and 15 kg/ha, and three rates of Mo, 0.2, 1.2, and 2.2 kg/ha, were applied in all combinations. Throughout the growing season, no visual deficiency symptoms were observed and there were no differences in carrot shape or color between treatments.

### **Blueberry**

*Select clones.* The 1978 plantings of root cuttings of the lowbush cultivars Chignecto and Augusta at Avondale overwintered with losses of 24.0% and 12.3%, respectively. The cumulative losses since planting amount to Augusta, 23.6%, and Chignecto, 47.2%.

An experiment to evaluate the effect of dolomitic limestone,  $MgSO_4$ , and  $CaSO_4$  on

the establishment and growth of select low-bush blueberry clones on peat soil was initiated in June 1979 at the Colinet bog. Examination of clones in late September showed no differences between treatments, and all plants were found to be in excellent condition.

## SOIL SCIENCE

### Peat soils

*Machinery.* Continuing trials on peat soils with the Engineering and Statistical Research Institute's articulated tractor showed that problems with steering were due to unsuitable track design. Further trials will be conducted in 1980 with an improved type rubber-cleat track assembly.

Field trials with the Memorial University designed ditcher revealed inadequacies involving the lifting and placement of the ditching impeller and with some components of the hydraulic system. These problems will be rectified for final field testing in 1980.

The rotoridger – precision seeder, also designed by Memorial University engineers, completed field trials and performed reasonably well. Minor problems with the precision seeder will be remedied for final field trials in 1980.

A second contracting-out program was awarded to Memorial University in July, involving design and construction of a root crop harvester and transporter and a peat bog cultivator. Both machines are in the design stage and are scheduled for completion in 1980.

*Revegetation.* Experiments on revegetation of mine tailings at Buchans and Baie Verte were conducted over the period 1974–1975. At Buchans, satisfactory stands of grasses and

birdsfoot trefoil were readily established on the relatively basic tailings (pH 6.4) and slimes (pH 5.6), with fertilizers only. In Baie Verte, growth of the same species was inadequate on high acid (pH 2.8) tailings, although limestone was applied at up to 36 t/ha.

During 1979 surface addition of 5 cm of peat, and limestone at 27 t/ha rotary cultivated in, followed by 10-20-20 fertilizer at 670 kg/ha, provided satisfactory stands of grasses and trefoil.

*Drainage.* The influence of drainage systems on water flow in peat soil at Colinet was determined by tipping-bucket metering devices. Plots provided with supplemental slit drains produced a faster flow during rainy periods but a reduced flow during dry spells. Comparisons of main drains of perforated corrugated pipe either embedded in sawdust or wrapped in fiber glass, and the standard Norwegian covered drain, showed little difference in ability to remove water, but the latter was more erratic due to its proneness to alternative muddying up and clearing.

In order to relate physical characteristics of peat to drainage requirements, comparisons were made between the Colinet site and a new commercial site near Botwood. Hydraulic conductivities were determined on vertical and horizontal core samples taken at a depth of 1 m at these sites. Hydraulic conductivities in a domed section of the Botwood site averaged 20 times those at the Colinet site, whereas values from peripheral low bogs at Botwood were about equivalent to Colinet. However, although the horizontal components were normally higher than the lateral ones at Colinet, the opposite was true at Botwood. These results would indicate that a much less intensive drainage system would be required on the domed Botwood site.

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# Research Station

## Charlottetown, Prince Edward Island

### PROFESSIONAL STAFF

L. B. MACLEOD, B.Sc. (Agr.), M.Sc., Ph.D.	Director
C. B. WILLIS, B.Sc. (Agr.), Ph.D.	Assistant Director
D. A. HUTCHINSON	Administrative Officer
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J. A. MACLEOD, B.Sc. (Agr.), M.Sc., Ph.D.	Nutrition (forage and cereal)
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J. KIMPINSKI, B.S.A., M.Sc., Ph.D.	Nematology
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H. T. KUNELIUS, B.Sc., M.Sc., Ph.D.	Physiology and management (forage)
J. A. McISAAC, <sup>2</sup> B.Sc.	Systems engineering
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K. A. WINTER, B.Sc. (Agr.), M.Sc., Ph.D.	Nutrition (cattle)

### Horticulture and Tobacco

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J. G. McDONALD, B.Sc. (Agr.), M.Sc., Ph.D.	Virus diseases (potato)
H. W. PLATT, B.Sc., Ph.D.	Diseases (potato)
J. B. SANDERSON, B.Sc. (Agr.)	Management and nutrition (potato)
D. C. READ, B.Sc. (Agr.), M.Sc., Ph.D.	Pesticide bioactivity, insects (vegetable)

### Departure

D. C. MUNRO, B.S.A., M.Sc. Died 15 March 1979	Nutrition (potato and vegetable)
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<sup>1</sup>Seconded from Libraries Division, Finance and Administration Branch.

<sup>2</sup>Seconded from Policy, Planning, and Economics Branch.

<sup>3</sup>On work transfer under CIDA from August 1978.

## INTRODUCTION

The Research Station at Charlottetown has Atlantic region responsibility for research on the production and utilization of livestock feed crops, tobacco, and certain vegetables grown for processing. Research is also conducted on potatoes, small fruits, and cattle nutrition and breeding.

We regret to record the death in March 1979 of Douglas C. Munro. Doug was widely recognized in the region for his research on the nutrition and management of potatoes and vegetable crops.

This report includes brief summaries of some of the research completed in 1979. More detailed information may be obtained from the publications listed or by contacting the Research Station. Copies of this report or of the publications listed may be obtained from: Research Station, Research Branch, Agriculture Canada, P.O. Box 1210, Charlottetown, P.E.I. C1A 7M8.

L. B. MacLeod  
Director

### CEREAL AND PROTEIN CROPS

#### Breeding and testing

*Barley.* The *Hordeum distichon* L. line AB53-4 (IB6-3/Volla/2/Mazurka) has performed well in two consecutive test years in the Maritime provinces. Yield and kernel quality were superior to the barley cultivars Atlanta and Summit, and the line is earlier maturing.

Treating the strong-strawed cultivar Bruce with the growth regulator Terpal (BASF) resulted in greatly increased yield and lodging resistance. In general, *Hordeum vulgare* L. cultivars responded favorably to Terpal treatment while *Hordeum distichon* L. types were affected adversely.

*Oats.* The new cultivar Lamar was superior to Laurent in resistance to lodging and in kernel quality; however, it yielded slightly less and was considerably later maturing. The cultivar Sentinel had the best combination of yield, kernel quality, lodging resistance, and tolerance to barley yellow dwarf virus.

*Spring wheat.* Two spring feed wheat cultivars, Dundas (2-3 days earlier maturity) and Vernon (resistant to powdery mildew), were licensed and released for production in the Maritime provinces. The earlier maturity of Dundas (Inia/Opal) reduced grain losses by allowing for earlier harvest. The resistance to powdery mildew of Vernon (Opal\*4/Pompe) resulted in increases in grain yield of up to 10% when this disease was a problem. Several promising new lines (AW3, AW4,

and AW7) showed yield improvement over Vernon. These lines have resistance to powdery mildew and some tolerance to *Fusarium*.

*Winter wheat.* The line T 1365-216 developed at the Ottawa Research Station performed well for 3 yr in the Maritime testing program. In 1979, it ranked first at all five locations of the Maritime winter wheat test. T 1365-216 is very similar to Lennox in all agronomic characteristics, but has greater consistency in performance from year to year. The Ottawa Research Station plans to apply for a license for this cultivar in 1980.

*Winter rye.* The European cultivar Animo was licensed for Maritime production. This variety has outyielded all cultivars in Maritime trials in the last 5 yr. Animo is similar to Kustro agronomically but has been slightly higher yielding from year to year. Six winter rye composites are being maintained for selection and generation advance. Of these, the composite CHR 75-2 has performed well in 2 yr of Maritime trials.

*Soybeans.* The recently licensed soybean cultivar Maple Presto was found to mature adequately. Although there were problems in obtaining good stands and harvest losses were greater than expected, results were generally promising.

*Doubled haploids.* A theoretical study showed that for self-pollinating crops, additive, additive  $\times$  additive, and additive  $\times$  additive  $\times$  additive genetic variances can be estimated from a diallel experiment in which

each cross is represented by a number of doubled haploid lines.

*Some oat lines more tolerant of barley yellow dwarf virus.* Oat lines and cultivars P1186606, RL608, Dorval, Sentinel, and Cabot were more tolerant of barley yellow dwarf virus (BYDV) than Laurent, Oxford, Lamar, Garry, Manic, Fundy, or Scott under light infection conditions in the field. Under severe conditions in the greenhouse, Sentinel and Fundy were more tolerant than Manic, while Alma was the most susceptible.

### Plant physiology

Second year results have shown a relationship between percent crown dry matter content and hardiness based on tests of entries in five winter wheat tests and one winter rye test. These results imply that it may be possible to use percent crown dry matter to screen for hardiness in winter wheat and winter rye germplasm.

A comparison of a number of tests to characterize cultivars of barley and wheat for moisture stress tolerance indicated that visual wilt ratings of plants, germination of seeds in mannitol solution, and measurement of water diffusion resistance were unsatisfactory. Plant survival following several cycles of moisture stress, root weight, water loss from leaves in 24 h, and differences in root and leaf weight in two soils of varying moisture-holding ability were satisfactory tests. The two semi-dwarf cultivars Pitic and Fielder, QB 59-28 unculm barley, and the two-rowed barley cultivars Volla and Nordal demonstrated superior moisture stress tolerance. No one single test appears to be sufficiently reliable, so that the use of at least two tests is recommended in screening material for moisture stress tolerance.

### Diseases

Head blights caused by *Fusarium graminearum* Schwabe have been identified as the cause of significant yield and quality losses in wheat.

Seed treatments, especially with Baytan (Chemagro Ltd.), effectively control powdery mildew, *Erysiphe graminis* DC. ex Méral f. sp. *tritici* Marchal, and increase grain yields substantially.

### Intensive cereal production

Results from intensive cereal production studies indicate that winter wheat yields can be increased using a combination of supplementary N applications, growth regulators for lodging control, and fungicides for disease control. With spring wheat, lodging was generally not a problem and disease control showed the most promise for increasing yields. Leaf disease control in intensive production studies has resulted in yield increases up to 1000 kg/ha.

### Tillage practices

In a 2 yr tillage study in which grain followed grain, potatoes, or sod, minimum tillage practices which permitted earlier seeding resulted in yields of barley equal to or greater than practices that included additional secondary tillage and, therefore, delayed seeding. There were no yield differences among moldboard plowing, chisel plowing, or heavy discing as primary tillage operations in grain stubble or potato land. In sod, moldboard plowing was superior to heavy discing. Tillage, in addition to that required to produce a level seedbed, resulted in no yield increase.

## FORAGE CROPS

### Management and nutrition

*Winter survival.* Statistical analysis, consisting of a combination of a ridge regression analysis and a stepwise multiple regression analysis of 5 yr data (1973–1977) from a survey in the Maritime provinces, identified major factors in winter survival of forage legumes. The analysis identified several critical factors which influenced winter survival of forage legumes, but a considerable portion of the variance remained unexplained. Snow cover was identified as the most critical factor. Among management practices, growing legumes with grasses, cutting frequency, and fall cutting date were significant factors. Drainage, soil texture, and frost heave were important soil-related factors. The analysis indicated that a number of other factors including direction and degree of slope, preceding crops, liming, and fertilization have no direct influence on winter survival.

A field study at Charlottetown showed that average survival percentages of *Medicago falcata* L., *M. media* Pers., and *M. sativa* L.

cultivars were 84, 55, and 31%, respectively. The hardiest alfalfa, *M. falcata*, however, did not tolerate a two-cutting system under the humid and warm summers in Prince Edward Island. Several promising cultivars of *M. media* survived better and produced higher dry matter yields than the recommended cultivars of *M. sativa*.

**Quality evaluation.** A gas-liquid chromatography (GLC) method for simultaneous determination of lactic acid and volatile fatty acids in silage was developed. The method eliminated the requirement to derivatize free acids prior to GLC. This was made possible by the use of a special column-packing material, a solid terephthalic acid support coated with poly-(ethylene glycol phthalic acid ester), on the surface of which the derivatization occurred automatically during GLC. With the new method, a complex mixture of fatty acids and lactic acid in silage can be analyzed simultaneously and accurately in 10 min, and the method is applicable to routine evaluation of silage quality.

**Increasing the Se content of forage crops.** The Se content of forages was increased by spraying a solution of sodium selenite on an established sward just as spring growth was starting. Applying Se at 0, 0.56, and 1.12 kg/ha gave 0.02, 0.32, and 0.54 ppm Se, respectively, in the first-cut forage and 0.03, 0.55, and 1.09 ppm Se, respectively, in the second-cut forage following application. The foliar spray method of application requires no tillage operations and permits established swards to be treated.

**Boron determination in soils.** A simplified method was developed for determining available B in soils using azomethine-H as the color-developing reagent. The interfering factors such as percent organic matter in soil, amount of charcoal added, and the stability of the color reagent were studied and suitable modifications made. The method is suitable for use by soil-testing laboratories.

**Boron deficiency symptoms in clovers.** Boron-deficient clover plants are weak and leaf margins often look burnt. The leaves of red clover turn red, become cupped, and shrivel in the case of severe B deficiency. Boron deficiency in Persian clover, *Trifolium resupinatum* L., occurs as a red coloration on the margins and tips of younger leaves. This coloration appears in other leaves with progression in time.

**Corn management.** Evaluation of tillage practices on corn production demonstrated a slight yield advantage for spring or fall plowing over spring discing, and continued declining yield with a no-till treatment.

Corn plants (DK-22) prevented from being pollinated gave an insignificantly lower silage yield, fewer broken stalks, and a significantly lower dry matter content (about 3%) than pollinated plants in a 2 yr study.

In a study of planting dates and plant populations, a plant population of 114 000 plants per hectare yielded 10% more silage than a population of 57 000 plants per hectare. High population densities did not reduce maturity, but increased the stalk breakage by 7%. Plantings from 10 May to 7 June gave equivalent yields, but a large reduction occurred with a 15 June planting; and dry matter levels at harvest decreased with planting delayed from 10 May to 15 June. The days between planting and emergence, as well as the days between emergence and silking, decreased with delayed planting.

In a comparison of European and Canadian hybrids grown at 50 000, 75 000, and 100 000 plants per hectare, the average silage dry matter yield was increased by 19% at the two higher populations, but percent dry matter in the silage dropped slightly. Increasing plant population to 75 000 and 100 000 plants per hectare decreased grain yields by 16 and 30%, respectively, and increased grain moisture content from 38.6 to 40.8 and 43.0%, respectively. There were obvious differences among hybrids in yield, maturity, and dry down rates both within and among populations.

### Insects and nematodes

**European corn borer affecting yields of crib corn.** Good control of the European corn borer, *Ostrinia nubilalis* (Hbn.), was obtained with several insecticides applied to Warwick TX17 corn. Yields of crib corn were significantly higher in treated plots than in the untreated check plots. Earlier studies showed that yields of corn grown for silage were not affected significantly by the borer. Percent protein was not affected by borer feeding. In a seeding date trial, more borer tunneling was observed, the earlier the corn was seeded; as well, stalk breakage was greater in earlier-seeded plots.

**Alfalfa blotch leafminer not reducing yields of alfalfa.** Three years of field tests

showed that the alfalfa blotch leafminer can be controlled successfully by insecticidal sprays, but the dry weight yields of alfalfa were not improved significantly by the control measures as compared with yields from untreated checks. The effect of leafminers on N, P, and K concentrations of alfalfa plants was not significant, but leafminers reduced concentrations of water-soluble carbohydrates in the leaves and stems. This suggests that the leafminer is affecting quality rather than quantity of alfalfa.

*Reproduction of root lesion nematode species on forage legumes and grasses and yield effects.* Studies with the root lesion nematode species *Pratylenchus penetrans* (Cobb) Filipjev & Stekh. and *P. crenatus* Loof have shown that the two species differ markedly in their reproduction on alfalfa, birdsfoot trefoil, red clover, brome grass, orchardgrass, and timothy, forage legumes and grasses commonly grown in Eastern Canada. *P. penetrans* reproduced well on alfalfa, birdsfoot trefoil, red clover, and timothy. Under the same conditions and on the same hosts, *P. crenatus* reproduced well only on timothy. *P. crenatus* did not maintain original inoculum numbers on alfalfa, birdsfoot trefoil, red clover, or brome grass. Forage yield from the legumes was reduced by *P. penetrans*, particularly for red clover and even more so for birdsfoot trefoil. *P. penetrans* infestation had no significant effect on the yield of grasses, nor did *P. crenatus* infestation affect yield of legumes or grasses.

*Influence of crops on numbers of root lesion and stunt nematodes.* The numbers of root lesion nematodes, *P. penetrans*, increased 25- and 50-fold in roots and soil, respectively, after 3 yr consecutively of corn. A red clover-timothy mixture, timothy, and wheat also supported substantial increases in the numbers of root lesion nematodes during the same period. However, nematode numbers declined in potato roots. In general, numbers of the stunt nematode, *Tylenchorhynchus dubius* (Bütschli) Filipjev, increased significantly in the soil of all crops except potatoes, but to a lesser extent than did *P. penetrans*. There was no indication of competition for food between the two nematode species.

## CATTLE

### Rations for early-weaned calves

Urea, as a source of supplemental N, and an ascomycetes yeast product were compared to a soybean meal starter ration for early-weaned calves. Calves on the urea-supplemented starter ration performed as well as those on the soybean meal control ration. Use of the yeast product did not improve growth rate or feed efficiency. The ability of the young calf to utilize urea in the starter ration indicates rapid development of rumen function in early-weaned calves. This supports a previous study in which dry matter digestibility just after weaning was similar for calves weaned at 3, 5, and 7 wk of age.

### Choice among feeder cattle alternatives

Costs and returns estimates for 10 feeder programs were prepared. The programs differed in beginning weight, length of keep, rate of gain, pasture usage, and season of purchase. Costs were estimated for each cattle class for rations having a maximum usage of each of low-quality hay, high-quality hay, grass silage, corn silage, and cull potatoes. Under the specific conditions used in the analyses, the more profitable feeding programs were those with rapid gains and low beginning weights. Cull potatoes and corn silage provided lower-cost rations than did the other feeds.

## HORTICULTURAL CROPS

### Potato management

Presprouting of seed-size tubers for 3-4 wk under light at 60-65°C resulted in an overall increase in stems per seed piece for Kennebec, Red Pontiac, and Sebago potatoes. However, there was a variety-by-planting date interaction. Sebago seed pieces had more stems with early planting (10 May), while Kennebec had more stems with later planting (23 May). Seed planted directly from regular storage was slower to emerge, especially for Sebago. Presprouting produced significantly more seed-size tubers (30-60 mm) as well as a greater total yield for all varieties. When presprouted, the three varieties produced equal amounts of small whole seed (10.7-11.5 t/ha) but Sebago produced only half as much yield of larger tubers when presprouted and only one-third as much yield as the other two



varieties when taken from regular storage. Early planting produced a significantly greater total yield but little difference in the yield of small whole seed.

A 20 cm in-row spacing produced more seed-size tubers (30–60 mm) and greater total yield than did a 28 cm spacing for six potato varieties (Kennebec, Sebago, Netted Gem, Red Pontiac, Katahdin, and Superior). Delaying top killing from 7 August to 21 August increased the total mean yield from 18.2 to 25.1 t/ha, but the mean yield for small whole seed increased only from 12.7 to 14.0 t/ha. The varieties differed both in yield and percent as small whole seed. Earlier studies showed that top killing in September increased the yield of small tubers at the closer spacing, but total yields were equivalent.

Both Kennebec and Sebago potatoes planted at 15, 20, and 28 cm in-row spacings were sampled every 7 days from 51 to 114 days after planting and sized into five ranges: 0–20, 21–40, 41–50, 61–80, and 80 mm cross-section. The data indicated the following trends: (a) the total yields and yields of tubers in the 21–60 mm ranges were greatest for the closest spacings; (b) the yield and numbers of tubers in the 21–40 mm size range increased rapidly from about day 50 to day 65 and then remained essentially similar; (c) the yield and numbers of tubers in the 41–60 mm range increased from about day 65 in Kennebec and from day 79–86 in Sebago right up to harvest on day 114; (d) yields for the 21–60 mm tubers at 15 cm spacing were approximately 16 and 17 t/ha at day 114 for Kennebec and Sebago, respectively; (e) the yields of tubers greater than 61 mm reached 17 t/ha for Sebago and 27 t/ha for Kennebec at 114 days with the close spacing; (f) maximum yields of tubers 21–60 mm appeared as early as about 80 days, with close spacing, but delayed harvest allowed additional production of tubers larger than 60 mm with only minimal decreases in the yield or number of tubers in the 21–60 mm range.

### Response of potato cultivars to metribuzin

Metribuzin applied preemergence and early postemergence (tops 12–15 cm) had no adverse effect on marketable and total yields of Irish Cobbler, Netted Gem, Kennebec, and Sebago potato cultivars. Delaying metribuzin application until late postemergence (tops 25–30 cm) resulted in significantly reduced

marketable yields of Irish Cobbler and Sebago, but not Netted Gem and Kennebec when compared with preemergence and early postemergence treatments. Total yields with late postemergence treatment were significantly less than those with the preemergence treatment for all four cultivars and significantly less than early postemergence treatment for Irish Cobbler and Sebago.

### Potato seedling evaluation

In studies evaluating horticultural characteristics of potato seedlings, a number of seedlings were recognized to have potential as early lines and as potential maincrop lines, and a number of yellow-fleshed seedlings were recommended for reexamination. Two promising seedlings will be recommended for licensing. In other studies, seedlings were found to possess high resistance to late blight and others carried resistance to three different storage rot diseases.

### Vegetable management and nutrition

*Effect of seed spacing and fertilizer on pea yields.* Field experiments conducted at three locations in Prince Edward Island showed that yields of Dark Skin Perfection (freezer) and Medalist (canner) peas were not substantially affected by seed spacing. Also, a preplant broadcast fertilizer treatment (15-15-15 at 392 kg/ha) failed to increase yields.

*Effects of added N on leaf tissue B concentration of cauliflower.* Applications of N prior to transplanting cauliflower resulted in increased leaf tissue B concentration at eight of nine sites studied during 3 yr. Similar experiments with Brussels sprouts showed a trend to increased leaf tissue B concentration where N was applied, but differences were usually not significant. Added P had very little effect on leaf tissue B concentration of cauliflower or Brussels sprouts.

*Seeding rutabagas on the flat.* Seeding on the flat rather than on traditional single-row raised beds had little effect on rutabaga yield in experiments conducted at four locations over a period of 2 yr. Also, seeding method had little effect on root shape or root exterior color.

*Effects of weed competition and weed control on rutabaga yields.* Delaying weed removal for 4 wk after crop emergence significantly reduced yields of marketable and total rutabaga roots compared with plots kept

weed free all season. Delayed weeding beyond 4 wk resulted in progressively greater reductions in yield. Rutabagas kept weed free for 2, 4, 6, and 8 wk from crop emergence by once-weekly weeding gave yields comparable to those kept weed free all season. Herbicide treatments without hand weeding gave significantly lower yields than those with one hand weeding. The use of three hand weedings with herbicides was not significantly better than herbicides with one hand weeding. Level of weed control was dependent on weed species present in the test area; however, a combination of trifluralin and niclofen gave a broader spectrum of control and better crop yields than either used alone.

## Vegetable storage study

A vegetable storage study was carried out to investigate the economic feasibility of storing locally grown carrots and cabbage for marketing in the Atlantic region in late winter and early spring. Common, refrigerated, and jacketed storages were considered for both vegetables. Considering the 5 yr average wholesale paying price and using storage loss estimates from the available literature, it was concluded that jacketed storages were the most profitable for carrots and common storages were the most profitable for cabbage.

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# Research Station

## Kentville, Nova Scotia

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T. A. VAN LUNEN, B.S.A.	Swine management and nutrition

## Departures

K. P. BUTLER, B.A. Resigned March 1979	Insect ecology, biometrics
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L. P. JACKSON, B.Sc. (Agr.), M.S.

Retired December 1979

C. R. MACEachern, B.Sc.

Retired October 1979

T. M. MACIntyre, B.Sc. (Agr.), M.S.

Retired June 1979

Weed physiology

Soil chemistry

Superintendent (Nappan); Livestock  
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## INTRODUCTION

This report summarizes the principal research results from the Research Station at Kentville and the Experimental Farm at Nappan for 1979. Kentville is the center for research in horticulture, poultry, food technology, and pesticide residues in the Atlantic Provinces. The Experimental Farm at Nappan, 80 km north of Kentville, serves as an associate establishment doing applied and developmental research on the production of cereals, forages, and lowbush blueberries, and on the management of livestock. The Atlantic region is characterized by a cool, humid climate and Podzol soils which sustain a diverse agriculture.

The construction at Kentville of the new office-laboratory complex for the federal and provincial departments of agriculture has made substantial progress during 1979.

This report summarizes the highlights of our research achievements in 1979. Highlights of research accomplishments include substantial increases in the yields of lowbush blueberries and remarkable gains in the growth rate of broiler chickens. Requests for further information or reprints of publications should be addressed to the Research Station, Research Branch, Agriculture Canada, Kentville, N.S. B4N 1J5.

G. M. Weaver  
Director

### BREEDING, NUTRITION, AND CULTURE OF CROPS

#### Lowbush blueberries

*The sweet lowbush blueberry. Vaccinium angustifolium* is a deciduous low shrub endemic to North America, whose range in Canada extends from the east coast of Newfoundland to Lake Winnipeg in Manitoba. It occurs from Quebec 57°N to Virginia 38°N. To produce fruit the flowers usually require cross-pollination by wild bees or related insects. The fruit of *V. angustifolium* is edible and matures during late summer. During the past 30 yr in the Atlantic Provinces of Canada many fields abandoned from other forms of agriculture have been brought into stands of this species by burn-pruning and selective weed control.

*Germination of lowbush blueberry seeds as affected by sizing, planting cover, storage, and pelleting.* Lowbush blueberry seeds that passed through a 30-mesh screen had a total germination of less than 3% while those that were retained germinated more than 35%. Covering the seed more than 5 mm with either sphagnum or peat reduced germination below no cover. Germination of seeds stored dry up to 24 wk was not affected by storage temperature but seeds stored moist during the same period showed reduced germination at both 0° and 21°C. Seeds larger than 30 mesh, when pelleted, germinated markedly better

over five planting dates than similar nonpelleted ones.

*Response of lowbush blueberry seedlings to various dates of digging for storage.* Seedlings of the lowbush blueberry (*Vaccinium angustifolium* Ait.) grew well after autumn digging, winter storage at -2°C, and dormant planting the following spring. Early November was the best digging time, as evidenced by plant survival and growth the following year.

*A comparison of fruit yields of lowbush blueberry clonal lines and related seedling progenies.* Up to 39 t/ha were obtained in three-harvest cumulative yields of superior lowbush blueberry materials planted in 1972 and harvested in 1974, 1976, and 1978. Plants from four select clones yielded an average of 50% more fruit than did their four respective seedling progenies. At a spacing of 20 000 plants/ha, 70% survived through the third fruiting season.

*Cultivar trials with the lowbush blueberry.* The planting out of fields to cultivars of the lowbush blueberry is quite recent. To date the following three cultivars have been named: Augusta, Brunswick, and Chignecto. Since yields have been almost as great with seedlings from superior clones as with rooted cuttings, and the cost of raising seedling plants is much less, growers are using seedlings rather than rooted cuttings. Yields two



or three times those from native stands are expected from such plantings.

### Strawberries

*Breeding for resistance to red stele.* Concern about the increase in the spread of red stele (*Phytophthora fragariae*) in Nova Scotia strawberry plantings has influenced the objectives of the Kentville breeding program. Much of the emphasis is now on the production of selections possessing a good level of field resistance to red stele. Seedlings (2787) derived from crosses involving one parent having multistrain resistance were planted in 1978 at Robinson's Corner, Lunenburg County, in soil known to be severely infected with red stele. There were 1259 apparently healthy plants at fruiting time in 1979. Red stele was evident in the roots of the obviously unhealthy plants. Twelve selections made in 1979 from the healthy plants have been propagated for further testing in red-stele-infected soil.

In addition, 4000 seedlings from crosses involving a multistrain-resistant parent crossed to superior cultivars or seedling selections were inoculated with a complex of the local strains of red stele. The inoculated seedlings were planted in a greenhouse during the 1979 winter in conditions conducive to the development of the red stele organism. The 1146 seedlings that did not become infected were planted in June at Robinson's Corner in red-stele-infected soil. Selections will be made from these seedlings in 1980.

### Raspberries

*Red raspberry breeding.* The principal objectives of the Kentville red raspberry breeding relate to cane hardiness, yield, fruit quality, disease, and insect resistance. Approximately 1000 new seedlings are planted each year from test crosses designed to produce 100 seedlings per test cross. To date, 207 selections have been made from more than 12 000 seedlings produced from 169 cross combinations. Progress has been made in attaining our primary objective of acceptable cane hardiness to our winter climate. To date, no test cross combination has been promising enough to repeat on a large scale. The cross Festival × K70-15 (Fairview × Boyne) which fruited in 1979 appeared, however, to be an exception. Four seedlings were selected from this cross in addition to 12

others from the 1300 seedlings producing their first full crop in 1979.

### Tomatoes

*Effect of fertilizer – trickle irrigation treatments on the marketable yield of the Cabot tomato.* A fertilizer ratio of 1-2-1 or 80 kg N, 160 kg P<sub>2</sub>O<sub>5</sub>, and 80 kg K<sub>2</sub>O per hectare consistently produced highest yields of marketable fruit from the Cabot tomato, with an average yield increase of 74 and 106% for 1978 and 1979, respectively, when compared with the ratio 0-1-1. Trickle irrigation gave an average yield increase of 54% in 1978 and 14% in 1979 compared with no irrigation. Substantial yield differences were recorded when the ratio 1-2-1, irrigated, was compared with 0-1-1, unirrigated, and these were 142 and 157% for 1978 and 1979, respectively.

### Apples

*A rapid method of determining the depth in sandy soils at which mechanical impedance will prevent growth of apple tree roots.* The sound produced when soil is tapped with the handle of a pointing trowel depends upon the degree of compaction. Provided a suitable trowel is used, a distinct ringing sound is produced by the trowel blade if soil is compact enough to prevent growth of apple roots. The method is relatively unaffected by soil moisture within the range of 4–30 cbar in soil that contains more than 60% sand.

### Oats

*Crude protein content of oat cultivars.* A number of oat cultivars were evaluated for their crude protein content at Nappan and Truro from 1973 to 1978. Dal, Otee, and Goodland averaged over 16% crude protein at the two locations, while three other cultivars, Hinoat, Chief, and Spear, averaged over 15% crude protein. The check cultivars Scott and Stormont both averaged over 13% protein. Nine of 14 cultivars evaluated produced crude protein yields of over 400 kg/ha. Proportion of hull varied from a high of 30.1% for Hinoat to a low of 24.2% for Stout. In vitro digestibility varied between 65 and 70%. Only the cultivars Scott, Hinoat, and Stormont are licensed for sale in Canada.

### Annual ryegrass

*Annual ryegrass cultivars recommended for licensing.* Two annual ryegrass cultivars were licensed and recommended in 1979,

Maris Ledger, an Italian pasture type, and Promenade, a Westerwolds silage or green chop type. This crop is gaining in importance in the region and has produced dry matter yields of over 4000 kg/ha under farm conditions. Protein content ranges from 18 to 26% and in vitro digestibilities have exceeded 70%. Yield potential is very high under good management practices. This crop has been used successfully for pasture, silage, green chop, and hay.

### Fall rye

*Superior performance from Animo fall rye.* Animo fall rye has been evaluated in the region, licensed, and recommended. It has been found superior to the recommended cultivar Kustro in yield, 6542 kg/ha compared to 6014 kg/ha at Kentville, and is very adaptable to the Annapolis Valley. At Nappan, Animo yielded 4672 kg/ha compared to Kustro with 4533 kg/ha. These cultivars were compared over a 6 yr period (1974–1979).

### Field peas

*Effect of delays in seeding field peas.* Field peas are growing in importance for livestock feed and human consumption. Two cultivars of field peas, Century and Trapper, were seeded in replicated trials on three different dates in the years 1976–1978 at the Experimental Farm, Nappan, N.S. Delays in seeding reduced the yield in most years and reduced the weight per 1000 K (kernels), but did not have much effect on crude protein content unless the delay seeding was exceptional. It was concluded, therefore, that seeding should be done in early May, and certainly not delayed beyond the first week of June. Very late seeding reduces yield and can cause harvesting problems due to poor trafficability on the soil in many areas of the region.

*New field pea variety licensed.* Lenca field peas have been licensed and will be recommended for use in 1981 when seed becomes available. This cultivar is similar to Century in growth habit and maturity but superior in yield.

### Ornamentals

*Nutrition and growth media for plants produced in containers.* Growth and foliar nutrient content of two ornamental species, *Juniperus* and *Euonymus*, were compared for plants cultured in different growth media and

supplied with various fertilizers. Three slow-release type fertilizers (SCU, Osmocote, and IBDU) were supplied at the start of the growing season followed by a standard fertilization regime (weekly irrigation with a 20-20-20 solution containing 300 ppm nitrogen) were used in combination with four growth mediums (soil, sawdust, soil with peat (3:1), and sawdust with peat (3:1)). The soil with peat medium produced the most growth and the best visual rating for plants during 1979. There were no interactions between growth medium and fertilizer. Weekly irrigation with 20-20-20 solution produced the most growth and the best visual rating. However, IBDU also produced good growth which continued longer than was observed with either SCU or Osmocote.

*Overwinter storage of plants grown in containers.* Four different methods of storage were used for containerized woody ornamentals which were used to compare temperature regimes and plant survival at two locations representing different plant hardiness zones in Nova Scotia. Storage facilities consisted of Quonset-style greenhouses covered with clear, opaque, or black polyethylene, and a blanket of flexible polystyrene (trade name Microfoam) which was placed over plants laid in rows on the ground. Preliminary results indicate that temperatures are maintained at the highest level underneath the Microfoam blanket while both opaque and black polyethylene-covered structures can maintain fairly constant root and stem zone temperatures.

*Improving salt tolerance of ornamental plants.* Salt tolerance of Yellow Twig dogwood (*Cornus stolonifera*), as judged by visual appearance and growth, was significantly improved by spraying with 4000 ppm of Cycocel (CCC). The treatment initially resulted in some leaf burning but this was not extensive. Plants which were sprayed and grown in a 3:1 sand-peat potting medium irrigated with salt solution containing NaCl at 4 g/L appeared to grow as well as those irrigated with water. Unsprayed plants grown in salt solution quickly showed growth reduction and subsequent leaf drop.

*Rhododendron breeding, cultivar and species testing.* Selections and evaluations of seedlings derived from the breeding program up to and including 1975 have continued

during 1979. Three highly promising seedlings selected during the year will undergo further evaluation during 1980.

## PROTECTION OF CROPS AGAINST PESTS

### Plant pathology

*Effect of fumigation with Vorlex on the growth of apple trees in replant soils.* In a pot bioassay test on soil for replant disease of apple, the fumigant Vorlex gave about the same growth response with Beautiful Arcade apple seedlings as the standard fumigant chloropicrin. The response did not differ with different rates of Vorlex. In a field test, all rates of Vorlex markedly increased tree growth, which increased as the rate of chemical applied was increased from 110 to 450 L/ha. The response at 450 L/ha was about the same as that with chloropicrin at 280 L/ha.

*Monitoring tolerance of apple scab to fungicides.* Isolates of the apple scab fungus, *Venturia inaequalis* (Cke.) Wint., tolerant to dodine were detected following the failure of dodine to control scab in apple orchards in which it had been used successfully for many years. The level of tolerance of isolates to dodine varied within and among orchards and increased over those isolated prior to use of dodine. Orchards appeared to fall into three groups according to the tolerance and susceptibility of the isolates present, namely: all isolates tolerant, a mixture of tolerant and susceptible isolates, or all isolates susceptible. The latter appeared to come from orchards in which dodine is still effective against scab.

*Control of red stele disease with fungicidal drenches.* Soil drenches of the systemic fungicide Aliette 80 WP [aluminum tris-(*O*-ethyl phosphonate)] prevented infection of susceptible strawberry plants, cv. Redcoat, when set in soil infested with the red stele fungus, *Phytophthora fragariae* Hickman. Yields from plants in drenched soil were nine times greater than yields from plants in untreated soil.

*Fruit rot pathogens and other fungi on fruit and leaves of lingenberry.* As part of the study of the biology and potential cultivation of native fruits, the fungal flora of fruit and leaves of lingenberry, *Vaccinium vitis-idaea*

var. *minor* Lodd, was investigated. Ten species of fungi were identified from healthy fruit, sixteen from diseased berries, and five from leaves. Three of the fungi, found on both diseased and healthy fruit, are the same fungi that cause storage rot of cranberries, *Vaccinium marocarpon* Ait. A new species of *Coniochaeta* occurred on fruit and leaves.

### Insect pests

*Observations on the white apple leaf hopper.* The white apple leaf hopper, *Typhlocyba pomaria* McA., with two generations per year, damages the leaves and defaces the fruit of apple. It was reduced in numbers in an experimental orchard by the predatory mirid *Blepharidopterus angulatus* (Fall.), which attacked the second generation. The coldhardiness of *T. pomaria* and *B. angulatus* overwintering eggs, which had mean freezing points of  $-35^{\circ}\text{C}$  and  $-34^{\circ}\text{C}$ , respectively, was sufficient to protect these species from winter low temperatures in Nova Scotia.

*Population trends and behavior of the pear rust mite.* The pear rust mite, *Epitimerus pyri* (Nal.), overwinters in a semiactive state in old leaf scar crevices and under bud chips of the leaf clusters. It becomes active within the bud in mid-April, as soon as the weather warms, and passes through three generations in the growing season as indicated by distinct peak egg populations observed in May, June, and July. The first-generation eggs are laid within the swelling bud. The mites feed on the ventral surface of the leaves causing bronzing and on the calyx end of the fruit resulting in russetting of the epidermal tissue. Deutogynes of the third generation begin to enter hibernation by mid-August. Occasionally population levels reach economic injury level, resulting in the downgrading of fruit.

*Pest damage and insect fauna of Nova Scotia apple orchards.* Annual assessments from 1953 to 1977 of insect damage to the preharvest crop in apple orchards in Nova Scotia show a general decline in injury, except for 1966–1968. *Laspeyresia pomonella* (L.) and fruit-chewing insects (chiefly *Operophtera brumata* (L.), *Alsophila pometaria* (L.), *Orthosia hibisci* Guenee, *Lithophane* spp., and *Xylena* spp.) caused the greatest amount of fruit damage. *Dysaphis plantaginea* (Pass.), *Campylomma verbasci* (Meyer), and *Atractotomus mali* (Meyer) were serious in some years. In integrated control program orchards the proportion of fruit damaged was

twice that in preventative pesticide orchards. Fruit destined for processing had more injury than fruit destined for the fresh fruit market.

Population levels of the major insect pests and their natural enemies were monitored regularly and gave early warning of threatened levels of pests. Generally, predator population levels were high during periods of selective insecticide use but were low when widely toxic insecticides were introduced into the integrated control program.

*Apple maggot.* Application dates for apple maggot sprays are usually based on adult emergence records obtained from ground emergence cages "salted" with infested apples from unsprayed or abandoned orchards. Emergence is generally substantial and provides the maximum period of the fly's appearance, which may or may not be representative of sprayed orchards with low levels of infestation. Subsequently, sprays based on these records could result in unneeded sprays in many orchards. Recently, it has been shown that the adults are strongly attracted to yellow rectangular sticky traps and that the need to spray and spray dates can be determined from capture data. The use of capture data to determine spray needs is preferred as it is more representative of adult activity in individual orchards and requires fewer sprays.

*Light trapping corn earworm and fall armyworm.* During the summer of 1978 a network of insect traps was deployed to selected areas in Nova Scotia. The 125 W mercury vapor and the 15 W Elisco traps were used. Corn earworm adults first appeared in large numbers in early August along the south coast of Nova Scotia, followed by a few individuals later in August in the west and central areas. A large number again appeared on the south coast during September, the south, west, and central areas in early September, and in all areas including the north shore in late September and October. Fall armyworm adults were found only on the south shore in August but showed up in all areas during September and October. The majority of the corn earworm moths were captured along the south and southwest coasts and the majority of fall armyworm were retrieved from the south coast. Although both species appeared at the same time, corn earworm moths were more commonly caught during early and late season, whereas fall

armyworm adults were more numerous during mid-season and were more widely distributed.

## Weeds

*The biology of Canadian weeds. Rubus hispidus L., trailing blackberry (Rosaceae),* occurs as a weed in cultivated bush and tree fruits, lowbush blueberries, cranberries, Christmas tree plantings, and waste places on a wide range of soil types in Eastern Canada. Its ability to regenerate from the crown or rhizomes following mowing, burning, or herbicide treatments makes it difficult to control.

*Control of eastern bracken.* Cutting once or twice per season for three successive years reduced regrowth of eastern bracken on midsummer treatment areas but not on early-summer treatments. Annual cutting was ineffective in eliminating bracken in a natural stand.

The selective herbicide asulam at 2.24 kg/ha suppressed 94–98% of bracken fronds in the year following application. Asulam in samples of ripe blueberry harvested 1 yr and 2 yr after treatment was less than the detection limit (0.05 ppm).

## Pesticide residues

*The thin-layer chromatographic (TLC) separation of halogenated fumigants as ammonium halides and their subsequent determination by MECA.* A method was developed for the determination of several pesticides containing bromine and chlorine by molecular emission cavity analysis (MECA). The pesticides were decomposed in an oxygen flash and the combustion products dissolved in aqueous ammonia. The ammonium halides were separated by TLC using microcrystalline cellulose adsorbent. After scraping from the TLC plates and dissolving in water, the separated components were quantitated by MECA using either the InBr ( $\lambda_{\max}$  376 nm) or the InCl ( $\lambda_{\max}$  360 nm) emission bands. Recoveries of over 96% were obtained.

*Movement and persistence of chlorbromuron in potato soil.* The movement and persistence of chlorbromuron with active ingredient applied at rates of 1.5, 3, and 6 kg/ha were studied in a New Brunswick potato soil for one growing season. Most of the chlorbromuron remained in the 0–2.5 cm soil depth with slight residues in the 2.5–5, 5–7.5, and 7.5–10 cm depths. After 47 days the chlorbromuron residues had dropped to 40%,

then gradually leveled off to 25% at the end of the season. Chlorbromuron was determined directly by electron capture gas chromatography using a short glass column of 3% OV-210.

## HARVESTING, STORAGE, AND PRESERVATION OF FOODS

*Identification of deformation parameters and fruit response to mechanical damage in sweet cherry.* The incidence of surface pitting and bruises in sweet cherries (*Prunus avium* L. cv. Van) increased with distance of free fall. Mature fruit developed less surface pitting but developed more flattened bruises than less-mature fruit in response to impact forces. Increased impact force applied to fruit resulted in a decrease in titratable acidity after storage. Fruit firmness and bioyield determined after storage increased to a maximum with the height of free fall to 45 cm for the intermediate fruit maturity only. A significantly higher incidence of surface pitting occurred when fruit contacted rough surfaces than when fruit was damaged by smooth surfaces.

*Effects of preharvest and postharvest calcium treatments on fruit calcium content and the susceptibility of Van cherry to impact damage.* Preharvest sprays or postharvest dips of  $\text{CaCl}_2$  decreased the incidence of surface pitting of Van cherries (*Prunus avium* L.) resulting from impact damage. Inclusion of a surfactant and thickener in the dip enhanced Ca uptake by cherries in storage. Ca from postharvest dips penetrated the cherry mesocarp rapidly in storage. Maximum Ca uptake by the cherry mesocarp was attained when the pH of the dipping solution was 7. However, postharvest Ca dips were most effective in preventing surface pitting when their pH was 4.

*Effects of a delay in storage and calcium chloride dip on surface disorder incidence in Van cherry.* A delay in storage at 0°C prior to impact damage decreased the incidence of surface disorders due to mechanical damage in Van cherries (*Prunus avium* L.). A 4%  $\text{CaCl}_2$  plus 0.25% Keltrol postharvest dip reduced the incidence of pitting and surface marking at all delay periods after dipping.

*Partial control of bitter pit in Northern Spy apples with a postharvest dip in calcium chloride solution.* Bitter pit of Northern Spy

apples that were stored in air in controlled-atmosphere (CA) storage was decreased by a postharvest dip in 4%  $\text{CaCl}_2$  solution containing 0.35% Keltrol. The calcium treatment also decreased breakdown, loss of fruit firmness, and fruit acidity, and increased Ca content of apple cortex tissue. There was no fruit injury. The dip treatments increased rots in one instance, presumably from dispersal of fungal spores during the dipping process and not due to an effect of calcium. Absorption of Ca was slightly greater in CA storage than in air storage. The percentage of apples with bitter pit (all treatments combined) was positively correlated with K content of leaf tissue, with Mg and K content of undipped fruit cortex tissue, and with (K + Mg):Ca ratios (eg:eg) of leaf and of undipped fruit cortex tissue. Leaf Ca was significantly related to pit when combined with leaf (K + Mg):Ca to multiple regressions.

*Texture modification of processed apple slices by a postharvest heat treatment.* Exposure of Spartan apples (*Malus pumila* Mill) to 38°C for 6 days immediately after harvest resulted in a significant reduction in softening during 4 mo cold storage. The heat treatment significantly depressed titratable acidity but did not affect soluble solids levels. After 6 mo cold storage the apples were prepared as thermally processed slices in retort pouches which were stored at 37°C for 16 wk before product quality was evaluated. Both shear force determinations and sensory analysis revealed that the postharvest heat treatment resulted in significantly firmer apple slices. Calcium dipping as a preprocess treatment also significantly increased apple firmness but control apple slices with calcium added were only as firm as heat-treated slices without added calcium. Color of the processed slices was slightly affected by the heat treatment but the flavor was not. The sensory panelists significantly preferred the 38°C postharvest heat-treated processed apple slices overall.

*Ammonia detection in controlled-atmosphere storage.* Direct expansion ammonia ( $\text{NH}_3$ ) refrigeration used in cooling many fruit and vegetable storages always presents a risk of  $\text{NH}_3$  leakage and resulting produce damage. A highly sensitive colorimetric procedure has been developed for detection of  $\text{NH}_3$  leaks in controlled-atmosphere storage rooms in which  $\text{NH}_3$  is used as the refrigerant.

*Effect of maturity and frost on the leaf color of storage cabbage.* Over a 3 yr period, storage cabbages were (a) harvested at different times or stages of maturity, and (b) harvested from frosted and nonfrosted plots. Three color component measurements of the wrapper leaves were taken during storage on a Hunterlab color and color difference meter. The early-harvested cabbages were variable for "L" lightness but were greener and less yellow than those from the later harvests or more mature specimens. Frosted cabbages were variable for greenness but were lighter and yellower than the ones that were not frosted.

*Pathogenic promotion of senescence in cabbage.* Ethylene production was stimulated by *Alternaria brassicicola* and *Botrytis cinerea* in closed culture with floating leaf discs from cabbage (*Brassica oleracea* var. *capitata*). Production with *A. brassicicola* had an observed maximum at 18°C and was speeded by preculturing the fungus on media containing cabbage components, but which contained little or no methionine.

In the absence of cabbage tissue, both organisms demonstrated a latent capacity to generate ethylene from closed shake cultures of Czapek's medium containing L-methionine. With *A. brassicicola* in a modified Czapek's medium (minus ferrous sulfate) containing  $10^{-3}$  M L-methionine, there was a stimulation of ethylene production at 18°C by the addition of  $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Cu}^{2+}$ , ca. 8% carbon dioxide, or the potassium salt of gibberellic acid ( $\text{GA}_3$ ). With *B. cinerea*, 4% carbon dioxide was stimulatory and 29% carbon dioxide was inhibitory, whereas less than 4% oxygen arrested the production of ethylene completely for 48 h.

Results suggest that the nature of parasitism of *A. brassicicola* and *B. cinerea* on cabbage is characterized by a latent capability to cause the production of, and to produce, the plant-senescing hormone ethylene.

*The role of endogenous acetaldehyde and ethanol in the prevention of greening in cold-stored Kennebec potato tubers.* Analyses of the gaseous content of cv. Kennebec potato tubers which received poststorage applications of aqueous surfactant emulsions formulated to prevent greening revealed minute increases ( $\sim 0.5$   $\mu\text{L/L}$ ) in internal acetaldehyde and ethanol content. When excised peel tissue was exposed to concentrations of acetaldehyde or ethanol of ca. 0.6  $\mu\text{L/L}$  for 6 days at 22°C

with a bench level illumination of 1100 lx cool white fluorescent, the chlorophyll production was halved. It was felt that reductions in peel chlorophyll previously attributed to an increased concentration of internal  $\text{CO}_2$  may also relate to the presence of the toxic volatiles of aerobic  $\text{CO}_2$  zymasis, viz. acetaldehyde and ethanol.

*The conception, development, and testing of a new blanching system for the food processing industry.* Blanching as a commercial process, though vitally necessary, tends to be energy intensive and high in effluent production, and in many cases significantly reduces the nutrient content of products. Over a 5 yr period a new prototype blancher has been developed which has been demonstrated to reduce energy requirements as much as 20 times when compared to conventional procedures. Most vegetables tested show ascorbic acid retentions of 85–90% of fresh and improvements in retention over water blanch processes of up to 52%. Effluent volumes and overall loads tend to be significantly reduced.

Extensive testing has shown the new process system provides significant improvements in the process parameters outlined above while yielding products of high quality, in many cases superior to conventionally processed products. A program is now under way to develop the system as a commercial entity. A unit capable of blanching peas at 2722 kg/h will be tested during the processing season of 1979.

## ANIMAL SCIENCE

### Cattle

*Effect of feeding rumensin to beef cows.* The feeding of rumensin to beef cows has consistently resulted in heavier body weights during pregnancy when feed intake is restricted as well as during lactation when feed is offered ad libitum. It has not adversely affected the rate of gain of calves being nursed by cows being fed rumensin, nor the reproductive performance of the cows.

### Sheep

*Dehydrated alfalfa as a grain substitute for ewes.* Dehydrated alfalfa proved to be an excellent substitute for grain in the diet of pregnant and lactating ewes. Alfalfa pellets were given in restricted amounts during gestation and ad libitum during lactation. At

weaning, ewes fed the conventional grain and hay diet weighed 54.9 kg, those fed alfalfa pellets 63.5 kg, and those fed a combination of alfalfa pellets and grain 65.8 kg. These results show that processed, high-quality forages can be used as a replacement for grains.

*Growth promotants for finishing lambs.* The addition of cement kiln dust as 2% of concentrate diet fed ad libitum to lambs resulted in a liveweight gain exceeding 30%. The addition of sodium bicarbonate at a 2% rate gave a weight gain response which was about 80% of that obtained with the addition of an equal amount of cement kiln dust. Similar results were obtained from a repeat experiment.

## Hogs

*Supplementing diets for feeder hogs with crystalline amino acids.* Results of research at Nappan indicate that the protein level of conventional starter, grower, and finisher diets may be reduced by as much as 2 percentums provided the diets are supplemented with low levels of the amino acids lysine, cystine, and methionine.

## Poultry

*Nutritional value and quality of squid (*Illex illecebrosus*) meal as source of dietary protein for broiler chicken.* Squid meal (SqM), produced by grinding and drying the whole squid (*Illex illecebrosus*) common to the northeast Atlantic and Mediterranean, had a protein content of 645 g/kg and appeared limiting with respect to lysine, methionine, and cystine. Although a comparison of the essential amino acid profiles of SqM with other protein concentrates indicated that SqM was higher than fish meal and soybean meal but lower than casein or whole-egg protein, these tests could not accurately predict protein quality.

A nutritional evaluation of SqM as a source of protein for poultry was carried out using 320 male and 320 female Cobb chicks fed to 48 days, a control diet with an SqM content of 50 g/kg fish meal or test diets with an SqM content of 50 g, 100 g, or 150 g/kg. Feeding SqM at a rate of up to 100 g/kg diet resulted in optimum biological response and monetary returns.

*Effects of using 0, 1.0, 1.5, and 2.0% Lignosol FG as a pellet binder in broiler chick finisher diets.* At slaughter age (47

days) cecal contents of birds on diets containing 2.0% Lignosol FG were gray black, shiny, and gelatinous. Lignosol FG used at and up to 1.5% of the diet had little or no abnormal effect on cecal contents. Histological examination of different regions of the digestive tract failed to reveal any significant abnormalities. The use of this pellet binder at different levels had no significant effect on performance.

*Effect of water sodium on the chick requirement for dietary sodium.* Broiler chicks fed a basal wheat-soybean diet designed to be complete in all known nutrients failed to achieve optimal growth at 3 wk of age. Increments of dietary sodium resulted in increased growth responses and improved feed efficiencies. The sodium requirement for optimum weight gain was found to be greater than the NRC (1971) requirement when the water sodium level was 3 ppm. The addition of 50 ppm of sodium to the drinking water improved growth and feed efficiency. When 100 ppm was added to the drinking water, a further increase in growth was obtained equivalent to that of birds receiving the basal diet to which increments of sodium were added up to 0.15%. Sodium in the drinking water was shown to be utilized more effectively than was sodium in the feed.

*Effect of four stocking densities on broiler carcass grade, incidence of breast blisters, and other performance traits.* A total of 3544 chicken broilers were housed at 3.72, 5.55, 7.44, and 9.27 dm<sup>2</sup> floor area per bird. Increased bird density resulted in a linear reduction in body weight of both males and females and adversely affected carcass quality. There was an increase in the incidence of breast blisters in both sexes. With increasing stocking density, monetary returns per bird started declining linearly but an opposite effect occurred when returns were based on units of floor area.

*Response of turkey broilers to different stocking densities, lighting treatments, toe clipping, and intermingling the sexes.* A total of 7428 turkey poults was used to evaluate the interrelated effects of stocking density, lighting, toe clipping, and intermingling the sexes. Mortality was unaffected by stocking density. Although high stocking density had the effect of reducing body weight and percent Grade A carcasses, monetary returns were highest per unit of floor area for birds grown under high

stocking density conditions. There was no apparent monetary advantage in extending the slaughter age from 98 to 119 days for males or by rearing the sexes separately to 14 wk of age. Body weights of birds grown under low-intensity green light were heaviest, but this was not reflected in higher monetary returns. There was no beneficial effect resulting from toe clipping. Body weight was adversely affected by toe clipping. In a windowless building, adequately ventilated, with the capability of maintaining low internal temperatures (not exceeding 21°C), high stocking density and low light intensity may be useful in the conservation of heat and light energy.

*Feed restriction during the juvenile and adult periods of meat breeder hens.* A comparison of skip-a-day feeding with ad libitum feeding during the growing period of meat breeders resulted in reduced body weights, heavier egg weight, increased numbers of hatching eggs, and higher fertility and hatchability so that more broiler chicks were produced per hen housed. Adult feed restriction compared to ad libitum feeding also resulted in reduced body weight. Although

egg production was reduced by the higher of two levels of restriction, egg weights were increased and the numbers of hatching eggs produced were increased. The higher hatchability associated with adult feed restriction contributed to an increase in the number of broiler chicks produced.

*Photoperiod effects on the performance of meat breeder hens.* Two photoperiod treatments were compared with a constant 14 h period of light per 24 h cycle. A "17-9-14 photoperiod" consisted of a daylength starting at 17 h at 1 day of age reduced by weekly decrements to 9 h at 140 days of age, then increased 30 min/wk until a 14 h day was achieved. In the second trial the 17-9-14 photoperiod was compared with a photoperiod which was increased from 12 h and 40 min to 15 h at 49 days of age, then decreased to 13 h at 133 days which was held constant to 147 days of age at which time it was increased 15 min/wk until a 15 h day was achieved at 197 days of age which was continued to the end of the lay period. The 17-9-14 photoperiod supported performance which was equal or superior to performance exhibited by birds under either the constant 14 h or the 12:40-15-13-15 h photoperiod.

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# Research Station

## Fredericton, New Brunswick

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C. D. MCLEOD, B.A.Sc., M.A.Sc.	Agricultural mechanization engineering
R. E. MCQUEEN, B.Sc., M.Sc., Ph.D.	Rumen microbiology
J. W. G. NICHOLSON, B.Sc., M.Sc., Ph.D.	Meat animal nutrition

### Potatoes

R. H. BAGNALL, B.Sc., M.Sc., Ph.D.	Virus resistance
G. BOITEAU, B.Sc., M.Sc., Ph.D.	Potato insect ecology
M. C. CLARK, B.Sc., Ph.D.	Biochemistry of disease resistance
W. K. COLEMAN, B.Sc., Ph.D.	Potato physiology
W. B. COLLINS, B.Sc., M.Sc., Ph.D.	Potato physiology

H. DEJONG, B.A., M.S., Ph.D.	Diploid breeding and genetics of potato
W. A. HODGSON, B.Sc., M.Sc.	Late blight of potato
G. R. JOHNSTON, B.S.A., M.S.A.	Potato breeding and evaluation
M. E. MACGILLIVRAY, B.A., M.Sc., D.Sc., F.E.S.C.	Potato insect ecology, aphid physiology
A. R. MCKENZIE, B.Sc., M.Sc., Ph.D.	Tuber-borne pathogens of potato
G. C. MISENER, B.Sc., M.Sc., Ph.D.	Potato harvesting and storage engineering
R. P. SINGH, B.Sc., M.Sc., Ph.D.	Virus diseases of potato
G. C. C. TAI, B.Sc., M.Sc., Ph.D.	Quantitative genetics of potato
T. R. TARŃ, B.Sc., Ph.D.	Cytogenetics of potato
D. A. YOUNG, B.Sc., M.Sc., Ph.D.	Potato breeding and genetics

### Small Fruits and Vegetables

P. V. LEBLANC, B.Sc., B.S.A.	Vegetables, Michaud Experimental Farm
C. D. MCLEOD, B.A.Sc., M.A.Sc.	Agricultural mechanization engineering
G. W. WOOD, B.Sc., M.A., Ph.D.	Blueberry pests

### Departures

E. A. GRANT, B.Sc., M.Sc. Retired 28 December 1979	Forage and cereal crops
J. G. KEMP, B.Eng. Retired 28 December 1979	Forage harvesting and storage engineering
C. H. LAWRENCE, B.Sc., M.Sc. Retired 28 December 1979	Tuber-borne pathogens of potato
G. M. WEAVER, B.Sc., Ph.D. Transferred to Research Station, Kentville, N.S., 30 March 1979	Director
F. J. WHITTEN Retired 28 December 1979	Administrative Officer

<sup>1</sup>Seconded from Libraries Division, Finance and Administration Branch.

## INTRODUCTION

The Fredericton Research Station is the main potato research center for the Research Branch of Agriculture Canada. Scientists of diverse disciplines integrate their expertise into a multidisciplinary program on breeding, pathology, pest management, physiology and nutrition, and handling and storage procedures. While their research, in the past, has been supportive of the industry for the Canadian market, it has recently been expanded to provide the technology for the export of seed potatoes, including cultivar evaluation in potential import countries.

The livestock program deals with cattle and sheep, and is pursued in close collaboration with the Nappan Experimental Farm of the Kentville Station.

The vegetable and berry crops program is receiving added emphasis since the acquisition of the Michaud Experimental Farm, purchased in 1978 specifically for this type of research. Up to now, efforts have been devoted mainly to land improvement in preparation for full-scale trials by 1980.

The environmental quality program has a broad spectrum of activities, dealing as much with maintaining the quality of the agricultural land base as preventing cultural practices from polluting the soil, the waterways, or the crops.

We note, in 1979, the departure of five worthy colleagues, and in particular the transfer of Dr. G. M. Weaver to his present position as Director of the Kentville Research Station.

The present report deals briefly with some of the on-going research and the results derived therefrom. More complete information is available by addressing requests to the Research Station, Research Branch, Agriculture Canada, Box 20280, Fredericton, N.B. E3B 4Z7.

C. S. Bernard  
Director

### ANIMAL NUTRITION AND LIVESTOCK FEEDS

#### Chemical changes in fermented colostrum

Previous studies have shown that colostrum preserved by fermentation will not support the same growth rate in calves as whole milk. During fermentation, chemical changes occur in the colostrum due to bacterial growth; these were measured over a 24 day fermentation period.

The main initial product of fermentation by the inoculum bacteria was lactic acid. Its production corresponded to a drop in pH and an increase in titratable acidity. As the fermentation proceeded, there was a second increase in titratable acidity due to the production of volatile fatty acids. Lactic acid and volatile fatty acids were end products of lactose metabolism. In four separate incubations with *Streptococcus lactis* approximately 60% of the lactose that was metabolized could be accounted for as acidic end products. Using yogurt bacteria, it was found that 70% of the lactose was acidic end products when the pH decreased to less than 4.1 and little volatile fatty acid was produced, but when the

pH was not sufficiently low only 47% of the lactose was accounted for.

As much as 35% of the colostrum protein has been shown to be metabolized to a nontrichloroacetic acid precipitable form during fermentation. This is frequently called nonprotein nitrogen (NPN) and has been assumed to be of no value to the calf. As a preruminant, the calf does not have a rumen microbial population capable of synthesizing amino acids and proteins from NPN. The NPN in the fermented colostrum was found to be 60% or more free amino acids and peptides, and less than 40% of the NPN was free ammonia. Therefore, much of the NPN provides useful nutrients for the calf.

#### Formalin-preserved colostrum

Formalin added to milk or colostrum at 0.1% (vol/vol) will inhibit bacterial growth without decreasing the palatability of the product for calves. The effects of formalin on chemical changes in colostrum were measured over a 24 day period.

Formalin treatment held the amount of lactose metabolized to less than 50% of the starting level. Therefore, less lactic acid was

produced, titratable acidity was greatly reduced, and the pH of the product was much greater than when colostrum was allowed to ferment. There were no volatile fatty acids produced in any formalin-treated samples. The NPN fraction did not increase by more than 5% during 24 days of storage. At least 80% of the NPN fraction was amino acids or peptides. It was concluded that 0.1% formalin was preferable to fermentation as a method of storing colostrum because there was much less chemical alteration of the preserved product.

### **Densely seeded corn for cattle**

Two fields were divided into halves and seeded to corn at the normal rate (60 000–65 000 plants per hectare) or densely (90 000–100 000 plants per hectare) in an attempt to increase the dry matter yield per hectare without adversely affecting plant maturity. The first field was harvested 21–22 September after slight frosting and the second field was harvested 3–4 October after severe frosting. Dry matter yield was increased by about 10% with dense seeding.

The early-harvested silages were fed ad libitum to dairy cows for 8 wk. Silage and total dry matter intakes were similar and the milk produced had the same fat and protein contents. Significant differences were detected ( $P < 0.05$ ) between the two silages in 4% fat corrected milk production and body weight gains. The early-harvested, densely seeded corn had less ear development, resulting in a silage with a reduced energy content and a lower feeding value for milk production.

The later-harvested corn was fed to beef calves. The animals fed the densely planted corn did not eat quite as much dry matter per day (5.42 versus 5.87 kg,  $P < 0.01$ ) nor gain weight as fast (1.38 versus 1.48 kg,  $P < 0.05$ ) as those fed the normal corn. However, because of the higher dry matter yield per hectare the densely planted corn produced 3038 kg of beef per hectare compared with 2750 kg for the normally seeded silage.

### **Red clover silage for steers**

Red clover is the most commonly grown hay crop legume in Eastern Canada but it is difficult to dry for hay and many farmers hesitate to preserve it as silage because of inconsistent quality. In this experiment the ensiling characteristics of a tetraploid cultivar, Hungarpoli, were compared with those of

a standard diploid cultivar, Ottawa. Both first and second cuttings were ensiled.

The silages were fed to beef calves ad libitum along with a supplement at 1 kg/day. The supplement fed to half of the calves contained monensin, which increased gains by 8% and the conversion of silage dry matter to weight gain by 9%. A preservative of 3% of a 9:1 mixture of barley and malted barley was added to the first-cut silage only. Silage quality and animal performance were excellent with all four silages. When ensiled without preservatives the tetraploid Hungarpoli red clover gave better results than the diploid Ottawa cultivar. Dry matter yields were 13% higher for the Hungarpoli cultivar.

### **Pesticide residues on potato vines**

Previously, we showed that potato vines harvested before senescence contain a useful level of nutrients for ruminants and after ensiling do not contain levels of glycoalkaloids likely to be harmful. Before vines can be recommended as feed, the levels of pesticide residues and their possible toxic effects on animals must be determined. In the summer of 1978 samples of potato vines were collected from 11 farmers' fields and from seven cultivars at the Benton Ridge Substation and analyzed for residues. The insecticides were present in only trace amounts but significant levels of the fungicides chlorothalonil and ethylenebisdithiocarbamate were found. Ethylene thiourea, an undesirable metabolite of ethylenebisdithiocarbamate, was not detected in either the fresh foliage or the silage. Additional work will be required before potato vines can be recommended as cattle feed.

### **Potato-hay silage made in winter**

Cull potatoes and chopped hay mixed at 3:1 (wt/wt) make excellent silage when ensiled in the fall. Cull potatoes are available throughout the winter but it was not known if they could be ensiled satisfactorily during cold weather. Preliminary observations with pulped potatoes and chopped hay ensiled in plastic bags and placed in a freezer, cooler, or open room (about 20°C) for 4 wk and then at room temperature for 4 wk indicated that satisfactory preservation would take place under these conditions.

In February 1978 upright, concrete stave silos were partly filled with 3:1 mixtures of potatoes with chopped grass or legume hay.

When opened, the silages had the characteristics of normal potato-hay silage, and chemical parameters measured indicated normal fermentation had occurred. The silages averaged 37% dry matter, silage dry matter consumption by beef steers averaged 7.56 kg/day, weight gains were 0.94 kg/day, and conversion of silage dry matter to gain was 8.1 kg/kg.

### Once-calved beef heifers

Calf production per animal maintained can be increased by calving out beef heifers intended for slaughter. A comparison was made between matched groups of open heifers marketed at 460 kg and heifers bred to calve before they were 24 mo of age. The bred heifers nursed their calves for 42 days before the calves were weaned and the heifers dried off and slaughtered. The open heifers had heavier carcass weights, 240 versus 225 kg, and higher average grades. At the prices prevailing, the average value for a carcass from the open heifers was \$713 versus \$656 for the bred heifers. The calves averaged 73 kg at weaning at 42 days of age and were valued at \$182 for a total return from the bred heifers of \$838. Offsetting the higher income was the extra 340 kg of feed dry matter consumed by the bred heifers at a cost of \$30. The bred heifers returned \$95 more over feed costs than did the open heifers. These results confirm previous observations that there is a considerable economic advantage to calving out beef heifers intended for slaughter.

### Cement kiln dust fed to cannulated sheep

Cement kiln dust supplementation of certain diets has given large increases in feed intake and rate of gain of ruminants. It is thought that the mode of action is by buffering digesta in certain segments of the digestive tract. A high-concentrate, ground diet was fed to sheep in metabolism cages and the pH of the digesta measured in the rumen, abomasum, duodenum, and feces. The diet was supplemented with 2% sodium bicarbonate and 2% or 4% cement kiln dust. As a result of frequent episodes of feed refusals, results obtained were highly variable. The pH of only the feces was consistently raised by the cement kiln dust. The fecal pH values were 6.70 for control, 6.62 for 2% sodium bicarbonate, 7.07 for 2% cement kiln dust, and 7.40 for 4% cement kiln dust. In the same treatment

order, rumen pH values were 6.50, 6.58, 6.46, and 6.45; abomasal pH 2.72, 2.73, 2.86, and 2.97; and duodenal pH 3.08, 3.27, 3.25, and 3.60. If the effect of cement dust is due to buffering, it must exert its influence in the lower part of the digestive tract.

### Weight loss on turnout to pasture

Young cattle that are well fed through the winter will lose up to 20% of body weight during the first 2 or 3 wk after turnout to pasture. It is widely assumed that this is mainly gut fill, but data collected here over the past 2 yr show this does not account for all the weight loss. On 29 May 1979, 10 heavy beef steers (average 484 kg) were turned out to pasture, while 10 paired steers were fed indoors. Two steers from each group were killed on 1 and 6 June and weekly thereafter until 27 June. For the five slaughter dates the matched inside-fed steers exceeded the pastured steers by 28, 54, 72, 68, and 63 kg for liveweight; 0, 21, 18, 26, and 28 kg for carcass weight; 15, 20, 41, 22, and 7 kg for rumen contents; and NA, 20, 46, 31, and 14 kg for total gastrointestinal tract.

A group of lighter beef steers (average 394 kg) lost 11% of body weight from turnout on 29 May to 13 June, when maximum weight loss was recorded, compared with 15% for the heavy steers described above and only 6% for a group of thinner Holstein heifers of about the same age (14–15 mo) and weight (406 kg) as the light steers. These data show that conditions of turnout affect weight loss, that loss of gut fill does not account for all the liveweight loss, and that there is a significant loss of carcass weight.

### White-rot fungi to improve digestibility of poplar shavings

The feasibility of using white-rot fungi to increase the digestibility of poplar shavings for ruminants was studied on a laboratory scale. Five species having the highest true protein contents in their mycelia when grown in liquid mediums were selected for study from a total of 18. Isolates of the five species *Polyporus anceps*, *Polyporus versicolor*, *Ganoderma applanatum*, *Phanerochaete chrysosporium*, and *Fomitopsis ulmaria* were studied for their ability to degrade lignin while sparing carbohydrate as they grew on poplar shavings. Static, semisolid fermentations were set up with a mixture of 10 g of shavings and 40 mL of a buffered minimal medium.

Weekly changes in chemical composition of the fermented mass and its *in vitro* rumen and cellulase digestibility were monitored. Maximum improvement in digestibility was obtained in 3 or 4 wk with four of the fungal strains. The maximum dry matter digestibilities were two to two and one-half times greater than the original poplar shavings and were similar to moderate to poor-quality grass hay. Lignin contents decreased with time and there was some reduction in the cellulose and hemicellulose contents during the fermentations.

### **Water vapor pressure variations over potato sap solutions**

The use of a vapor compressor to recycle the latent heat of evaporation, when removing water from potato, requires identification of certain characteristics of the solution. Of interest is the behavior of the water vapor pressure of the solution during solute concentration and identification of that point at which precipitation becomes a problem for heat-exchanger surfaces. In an environment where such variables as surface area, diffusivity, sink vapor pressure, and temperature can be controlled, then the variation of the rate of change of solvent mass flow is proportional to the vapor pressure of the solvent. A sample of potato sap was placed in a container floating on a saturated salt solution in a vacuum chamber and the pressure was reduced to 3 cm Hg. After a time limit, the pressure is increased, the sample is removed and weighed, and the process is repeated until the change in weight from the previous sample is small. Curves of the moisture content versus time are plotted and the moisture ratio is plotted against the pressure ratio. For a given moisture content, an appropriate vapor pressure can be found and the energy required to recycle the latent heat can be estimated. The main restriction with these data at this time is the temperature, because the process has been done only for one, and extrapolation to any other temperature could be inaccurate. The second limiting condition is the difficulty in determining the exact point at which precipitation occurs if precipitation is to be avoided. There is a chance that it can be occurring much earlier in the drying process than originally expected and may not be practically avoidable in a system processing liquid fractions.

### **Vacuum chamber design for measuring continuous water vapor flow**

A special vacuum chamber was designed that allows continuous measurement of water being removed from a sap solution extracted from a biological material source. The vacuum is required for high rates of moisture removal but generally creates a problem for measuring changes occurring within that vacuum. The chamber maintains a constant temperature and keeps a constant vapor pressure sink in which to condense the water vapor.

All these characteristics are obtained by using a saturated salt solution in the chamber and floating a thin-walled container filled with sap solution on the salt solution. This maintains a constant temperature (differential) between source and sink while providing a constant vapor pressure sink.

As the water vapor transfers from the sap solution to the sink, the level in the sink raises and the weight in the solution container drops. The upward buoyancy force increases with the increased displacement and, when the container is held in place by a compression load cell, the buoyancy force is measured on the load cell. As the load increases on the load cell, its displacement increases and, by designing a linkage that in effect cancels the rise in the salt solution level with the corresponding displacement in the load cell, then the output of the load cell is linear and is a direct reading of the weight of water evaporate in millivolts. For a given load cell (maximum characteristic load and deflection), there is an area ratio between sap container surface and saturated salt solution surface such that a calculated linkage (unique to this ratio, load, and deflection) allows the load cell to give a linear response independent of the density of the saturated salt solution.

An instrument was built and calibrated and found to be particularly sensitive. Its sensitivity to atmospheric temperature and pressure changes is creating some operating problems.

## **POTATO BREEDING**

### **Comparison of expected response to selection between traits**

Expected response to selection ( $R$ ) can be estimated from data of progeny test experiments. It is used for comparing the efficiency



of different selection schemes for a quantitative trait. A method of establishing confidence intervals for  $R$  is proposed by Tai (Theor. Appl. Genet. 54:273-275; 1979). The  $R$  values, however, cannot be used for comparing selection progress between traits because they are measured in different physical units. One way to remedy this situation is to express the genetic advance due to selection in terms of the population mean. This provides the relative expected response to selection ( $R_v$ ). A confidence interval for  $R_v$  can be derived using an approach similar to the one reported by Tai (1979).

Data on six quantitative traits were collected from a 3 yr progeny test experiment involving 465 seedlings of 25 crosses.  $R_v$  values were estimated for one up to several years' theoretical testing period. Marketable yield, followed by maturity, shows larger expected response to selection than tuber appearance, tuber number, mean tuber weight, and specific gravity. Genetic gains are increased with more years of testing. The additional gains over those of a single-year testing, however, are not substantial. Marketable yield, for example, gives only an additional 10% gain for a 4 yr testing period over the 37% gain obtained from a single-year testing. Evaluation and screening of breeding materials at the early stage of a potato breeding program may be most economically carried out by a single-year field test.

#### **Utilization of Andigena germ plasm in potato breeding**

A 1979 field trial compared 14 crosses between Tuberosum and long-day adapted Andigena (TA) with eight Tuberosum  $\times$  Tuberosum (TT) crosses and most of the Tuberosum (T) and Andigena (A) parents. The results reemphasized the heterosis obtained in TA crosses and suggested a breeding strategy to make best use of Andigena parents. Each cross was represented by 30 randomly selected clones, the parents were replicated three times, and all plots contained eight hills. The T parent values used for comparisons include data from T parents of both TT and TA crosses.

Compared with the mean of the T parents, the TT progeny had considerably less early vigor, more midseason vigor, and considerably later maturity; they had 4% more tubers and 6% smaller tubers for a 5% reduction in total yield and a 14% reduction in marketable

yield. This yield reduction is typical of the inbreeding depression in conventional TT crosses.

The TA progeny had moderately less vigor, moderately more midseason vigor, and considerably later maturity than the T parents. The tuber number was 60% greater and the tuber size 28% smaller than in the T parents. Heterosis for total yield showed in the 11% increase over the high (T) parents, though marketable yield was reduced by 23%.

The breeding value of the TA crosses is seen in their superiority over the TT crosses. The TA crosses were considerably more vigorous at emergence, slightly more vigorous at midseason, and slightly later at maturity. The TA tuber numbers were 53% greater, and the size 23% smaller than in the TT progeny. Total yields were 17% greater while marketable yields were only 10% smaller. The best TA cross had a mean marketable yield (6.63 kg) greater than that of its own T parent (6.26 kg) and the mean of all T parents (6.33 kg). The performance of the TA crosses in relation to their parents and TT crosses, as evaluated in two-dimensional canonical diagrams, suggests that back-crossing selected TA clones to Tuberosum will bring further improvements.

#### **Incorporation of potato germ plasm from South American cultivated diploids**

Three cycles have been completed of a recurrent mass selection procedure to utilize germ plasm from South American diploids in the production of potato cultivars adapted to Canadian conditions. Selection criteria include tuberization under long days, storability (including dormancy), and other horticultural traits. A parallel population of diploid Tuberosum (haploid Tuberosum  $\times$  haploid Tuberosum) is being developed. Advanced diploid hybrids (Phureja or Stenotomum  $\times$  diploid Tuberosum) have been crossed with Tuberosum cultivars and breeding stocks. Several hybrids from these  $4\times-2\times$  crosses continued to lead the major cultivars in Canada in terms of marketable yield.

#### **Breeding and evaluating potato varieties for Ontario**

Potato seedling G6457-5R, bred at the University of Guelph by G. R. Johnston (seconded to the university by Agriculture Canada's Fredericton, N.B., Research Station), was granted a permanent license in

Canada as the potato variety Rideau. It is a main-crop potato variety with bright red skin and very white flesh, and with high quality as table stock. It has high resistance to verticillium wilt races and moderate resistance to mosaic-type viruses.

Two advanced, promising Guelph-bred "candidate" potato varieties, G6666-4y and G6880-1, were multiplied as Pre-elite and Elite 1 seed in 1979. G6666-4y will be recommended for licensing in 1980. It is yellow fleshed, early in maturity, with pink eyes and yellowish skin. It is a good table-stock variety that also has very good French fry processing ability. G6880-1 is an early-maturing, round, white-skinned potato with very good table-stock quality and excellent chipping ability.

#### **F69016—a promising French fry seedling**

Fredericton seedling F69016 continued outstanding in yield and grower trials in New Brunswick and Prince Edward Island during 1979, and as a result, steps will be taken to license and introduce it for commercial production.

F69016 led a trial of 12 French fry type varieties with a marketable yield of 33.5 t/ha, 15.5% of yield > 284 g tubers, and a specific gravity of 1.080, as compared to 23.5 t/ha, 3.2% > 284 g tubers, and a specific gravity of 1.080 for Netted Gem. In a whole versus cut seed and spacing trial (30 cm, 36 cm, 41 cm), marketable yield was not affected by treatment. However, the number of small tubers was reduced and the number of tubers > 284 g increased when using cut seed spaced at 36 and 41 cm. Marketable yield and size distribution were not affected as N, P, and K (1-1-1) were increased from 109 to 134 to 168 kg/ha, although specific gravity was reduced from 1.086 to 1.085 to 1.082, respectively.

Commercial-scale processing trials in both New Brunswick and Prince Edward Island produced French fries of excellent quality.

## **POTATO PATHOLOGY**

### **Purification and serology of potato viruses A and Y**

Potato viruses A and Y were purified from *Nicandra physalodes* (L.) Gaertn. and *Nicotiana tabacum* 'Samsun', respectively. Virus yields of 1.8–2.2 mg/100 g of leaf tissue were routinely obtained. The purified virus was injected intramuscularly into rabbits, which

were bled 2 wk after the last injection. In enzyme-linked immunosorbent assay (ELISA) tests with crude extracts, a concentration of 1–5  $\mu\text{g/mL}$  of  $\gamma$ -globulin and a dilution of 1:200 of enzyme conjugate proved to be optimum. Testing of different plant parts indicated that both viruses were more readily detected from fully expanded leaves than in the top young leaves of the potato plant. When PVA and PVY antisera were tested against PVA- and PVY-infected leaves, strong homologous reactions were obtained.

Samples of leaves from plants showing mosaic symptoms in the field were tested by ELISA and by infecting indicator plants. One-third were diagnosed as infected by PVA alone and two-thirds were infected with PVY alone. There was good correlation between ELISA readings and those obtained with indicator plants. Six potato seed fields were surveyed throughout the summer of 1979 and 600 samples were tested each week by ELISA. The results pointed out the possibility of monitoring potato fields for incidence of PVA and PVY using ELISA technique.

### **Virazole as aphid sterilant**

Virazole, a synthetic nucleoside analogue (1-B-D-ribofuranosyl-1,2,4-triazole-3-carboxamide) suppressed the production of aphid nymphs when systemically applied to plants. The nymphs were killed either inside the abdomen of the mother aphid or after birth. The treated adults were unable to reproduce. In addition, the aphids grown on virazole-treated plants failed to acquire and transmit potato leaf roll virus. Although virazole is reported as a broad-spectrum antiviral agent, it also affects aphid reproduction, which could be beneficial for aphid control.

### **Hawkbit mosaic**

Fall hawkbit, *Leontodon autumnalis* L., a common perennial weed in the Atlantic provinces, was surveyed for viruslike symptoms. Some of the plants were found with chlorotic mosaic symptoms on the leaves. Because symptoms resembled those caused by tobacco rattle virus in other plants related to hawkbit, and tobacco rattle virus is not known to occur in Canada, an attempt was made to identify the virus causing chlorotic mosaic in hawkbit. A short rigid rod-shaped virus, with particle sizes of 150 and 170 nm, was found associated with diseased plants. Antisera to five isolates of tobacco rattle virus and related

pea early browning virus failed to react with hawkbit virus-infected tobacco sap in sodium dodecyl sulfate-agar diffusion tests. However, a specific reaction was observed with an antiserum prepared against *Hypochoeris* mosaic, a newly described virus from Western Canada.

### **Comparison of three methods for the detection of *Corynebacterium sepedonicum***

Seed potato inspectors are well trained in identifying field or tuber symptoms of bacterial ring rot and the Gram stain has worked well in confirmation of the visible symptoms of single samples. However, in 1979, a program was initiated to eradicate ring rot from table and processing potato fields in New Brunswick. Many of those inspecting the nonseed potato fields were not familiar with the symptoms; as a result, samples were received of plants with symptoms varying from slight chlorosis through severe wilting to leaf yellowing and necrosis, representing different abnormalities ranging from environmental wilting and late blight to bacterial ring rot. We compared the Gram stain, latex agglutination (LAT), and immunofluorescence (IMF) tests on material from both individual (163) and bulked (85) samples.

LAT was more sensitive than Gram stain on individual stems (41) from a single field, giving 25% more positive reactions. Subsequent testing on the stems and on tubers from the same plants confirmed the presence of *C. sepedonicum*. On individual tubers we observed a complete correspondence between LAT and Gram stain observations. The IMF on these tubers tended to confirm the positives observed with LAT and Gram, but another 15% of the samples were rated as inconclusive IMF and negative LAT and Gram.

The stem ends of up to 500 tubers were treated together as individual bulked samples. The known controls (9) were from tubers derived from disease-indexed stem cuttings without (negative) or with (positive) one stem end from a tuber infected with *C. sepedonicum*. All the controls were accurately diagnosed with LAT. In addition, one unknown sample was diagnosed positive, and later verified with the discovery of tubers with visible symptoms. One positive control was verified with the Gram stain, but the dilution effect was too great to read accurately with these bulked samples. The IMF observations were inconclusive with all bulked samples.

Under our conditions, the LAT is more sensitive and accurate in confirming known positive infections and in diagnosing unknowns. The Gram stain is adequate on single samples to confirm visual diagnoses. The IMF is not reliable. Problems encountered included autofluorescence of potato tissue and numerous fluorescing bacteria of differing sizes and shapes, including some approaching that of *C. sepedonicum*.

### **Simplified procedure for PVS antiserum production**

A simplified procedure has been developed for the preparation of potato virus S as an antigen. Sap from potato leaves, combined with buffer, containing chelating and reducing agents was first cleared of crude material and then centrifuged at high speed over a layer of 60% sucrose. The pellet was redissolved in phosphate-buffered saline, spun once at low speed, and the supernatant checked for anisotropy of flow before being used as antigen. Intramuscular injection of rabbits, using Freund's incomplete adjuvant, has produced PVS antiserum with tube precipitin titers of 1/32 000, and quality suitable for the latex agglutination test.

### **Natural spread of potato viruses S and Y**

In 1978 and 1979, spread of PVS and PVY into previously healthy plots of the cultivar Netted Gem was monitored at intervals by subinoculation of leaf samples to *Nicotiana debneyi*. The two viruses were first detected, though not necessarily on the same plants, in plots nearest to sources of infection on 28 July in 1978 and 16 August in 1979. Probably because of the early start, spread of both viruses was considerably more intense and prolonged in 1978. Further, initial detection in the respective years followed by approximately 3 wk the initial trapping of *Myzus persicae*, suspected as a principal natural vector of each virus. In plots 30 m from sources, infections were detected later and less frequently; and at 400 m, occasionally in 1978, but not at all in 1979.

### **Zoospore encystment in *Phytophthora infestans***

The results of biochemical and ultrastructural studies of the encystment process in *P. infestans*, the organism causing late blight in potatoes, suggest that the events underlying cell wall formation following cessation of the

## POTATO ENTOMOLOGY

### Oil sprays against mosaic of potatoes

A procedure was developed, using thin layer chromatography, for the measurement of oils on potato foliage surface as well as that which infiltrated the foliage. In a field trial, eight mineral oils applied as 1% emulsions were compared. Concentrations fell to pre-treatment level after 5–7 days, indicating that for crop protection sprays may have to be applied at 5 day intervals. None of the oils in this trial had any significant effect on the growth of the plant or its yield.

### Control of the Colorado potato beetle

A cooperative research program with the New Brunswick Research and Productivity Council was started to study the feasibility of using pheromones for the control of Colorado potato beetles, *Leptinotarsa decemlineata*. Suitable rearing techniques were developed. Laboratory tests confirmed the existence of a specific sex pheromone, and its chemical composition is being analyzed. Male beetles without functional palpi were found to be as incapable of recognizing female beetles as male beetles without functional antennae. Further studies on the reproductive biology of the potato beetle have shown that the mating periodicity is strongly affected by the onset of the photoperiod but seems unaffected by the intensity of the light during the photoperiod.

During the course of rearing Colorado potato beetles, we obtained a color morph, which differs from the normal brown morph in being predominantly white. It is similar to *L. pallida*, a mutant strain reported once in the USA by Tower in 1906. This is the first record for this morph in Canada.

### Aphid warning systems—density maps

Aphid density maps portraying the potential probability of potato leaf roll virus infection in an area have proven useful in New Brunswick as a warning service to seed and processing growers. The maps, issued to growers weekly, after the first catches of green peach aphids, present pictorially the Saint John River valley in Carleton and Victoria counties, the major potato-producing areas. Dark areas on the map are where the potential for PLRV spread is greatest and the hazard is high. After studying the maps, potato growers are better able to judge if their

motile phase differ in a number of important respects from the conventional interpretation. Accordingly, a model is proposed to account for the form and structure of the encysted zoospore. Ostensibly, during or even before retraction of the flagella at the termination of motility, vesicular elements become attached to the inner surface of the zoospore membrane where they subsequently fuse with the membrane and deposit their contents on the outer surface to form an amorphous layer over the entire membrane surface. This layer acts as a base for the laying down of a fibrillar network of polysaccharide that provides some rigidity to the zoospore. The reticulate structure composed of many irregular ridges of varying thickness is clearly evident in scanning electron microscopic analysis.

It is also clear from such scans that the encysted zoospores become anchored in Lilliputian fashion by a number of threadlike fibers to whatever surface they are resting on. In no case were these filaments observed to originate from the germ tube itself in the more mature zoospores, but in all instances they were attached to the main body of the zoospore. It remains to be determined whether or not these attachment fibers can play a role in providing for adhesion of the zoospore to the leaf or tuber surface, thereby allowing for penetration by an infection peg without the intervention of an appressorium.

### Late blight forecasting

A model previously developed to forecast the probable date of potato late blight outbreaks was tested using current hourly weather data on humidity and temperature from Environment Canada offices in Charlottetown and Summerside, P.E.I.; Greenwood, N.S.; and Fredericton and Woodstock, N.B. The model was also used to interpret data from hygrothermographs located in the potato fields of four cooperating potato growers near Grand Falls, N.B. A further test was made using humidity and temperature data from previous years that were not used in the development of the model. The results of all tests showed that the model could be successfully used to forecast the date of disease outbreak.

fields are in a zone of high hazard and if top killing is necessary.

## POTATO PHYSIOLOGY AND CROP MANAGEMENT

### Growth analysis of Netted Gem and F69016

The potato clone F69016 shows promise as a high-yielding cultivar with processing characteristics comparable to the present standard, Netted Gem. Consequently, a comparative growth analysis was carried out during the summer and fall of 1979.

The capacity of F69016 to partition biological energy into tubers was greater than Netted Gem, when expressed in terms of harvest index (i.e. ratio of tuber dry matter to total plant dry matter). The major limiting factors of economic yield in both cultivars were tuber growth rate and length of growing season, not the number of tubers initiated. Netted Gem and F69016 had similar levels of tuber dry matter after 100 days. The variation of dry matter content in different-sized tubers was similar also. F69016 was less susceptible to "second growth" (i.e. knobby tubers), hollow heart, and external splitting than Netted Gem. And unlike Netted Gem, the majority of F69016 plants after 115 days continued to possess an intact seed piece that may have served as a water-nutrient reservoir against short-term environmental fluctuations. Thicker stems in F69016 may have had a similar effect.

### Ultrastructure of potato tuber microbodies

As an adjunct to studies aimed at screening potato cultivars for their capacity to photore-spire, an attempt was made to follow microbody development in potato tubers. Electron micrographs of tuber sections obtained from small aseptically cultured tubers and from mature field-grown tubers, *Solanum tuberosum* L. 'Green Mountain', revealed that the microbodies were similar to those found in other plants and bore little resemblance to the multifunctional plastids observed by others in tuber bud tissue. The major discernible difference between the microbodies from the two types of tubers was in their size: the diameter of microbodies in the cultured tubers averaged 320 nm whereas those in the field-grown tubers had a mean diameter of 800 nm. Microbodies from both

sources were bounded by a single unit membrane that contained a solitary crystalline inclusion. They also possessed a matrix that was moderately electron-dense and finely granular.

In cultured tubers the smaller the microbody, the larger the proportion of its volume that was occupied by a crystalline inclusion and the less evident was the matrix. The rhomboidal shape of the inclusions appeared to develop only after the matrix outgrew the inclusion during the ontogeny of the microbodies. In no instance was there any evidence of microbodies directly connected to the endoplasmic reticulum.

### Evaluation of potato planters

A 3 yr evaluation of the seed piece distribution patterns achieved by three types of potato planters was completed. The planters were divided into three groups—pick, cup, and tuber unit. The pick type is the predominant planter being used in North America. However, cup and tuber unit planters are becoming more popular in some areas.

Seed piece placement was measured for 13 planters over a total of 300 trials. The study included five cup-type, three pick-type, and five tuber-unit machines. Coefficients of variation of spacing, number of seed piece skips, and number of seed piece doubles were determined for each planter. Results from the study indicate that the percentage of skips ranged from 0 to 24.6%, with an average of 6.5%. In general, there was a higher number of doubles than skips with all planters. The average number of doubles for the study was 16.2%. The coefficient of variation of spacing ranged from 47.8 to 87.1% for the three types of planters. The cup planter performed best when planting either whole seed or large cut seed. More doubles were found when planting small cut seed. In general, seed pieces were found to be more evenly spaced with the tuber unit planter.

### Effect of amendments on physical properties of compact basal till and alfalfa yield

Field experiments have indicated that amendments (sawdust, lime, and manure) when incorporated in the subsoil increased alfalfa yield about four times as compared to the control. However, the use of 3,5-diiodo-4-hydroxybenzoic acid (DIHB) in the topsoil gave only a 46% higher yield than the control. Mean dry matter yield (grams per plot) were

control 24.1; DIHB 35.1; loosened subsoil 53.6; loosened subsoil plus sawdust 120.4; loosened subsoil plus lime 120.1; loosened subsoil plus manure 132.4. Measurements of oxygen diffusion rates (ODR), saturated hydraulic conductivity ( $K_s$ ), and soil water matric potential ( $\psi_m$ ) in the greenhouse experiments indicated that the use of sawdust may cause excessive drainage and moisture stress.

### **Time of application of fertilizer nitrogen for potatoes**

In an attempt to improve the efficiency of utilization of fertilizer nitrogen by the potato crop, ammonium nitrate was applied as a side dressing during the early to posttuberization period 24 June to 7 August at four times, at rates varying from 22 to 88 kg/ha. Yields of the cultivar Kennebec were not increased by supplementary nitrogen in any of the 3 yr of the experiment, provided adequate nitrogen was applied at time of planting. The latter requirement ranged from 135 to 160 kg/ha and produced a mean yield of 28.8 t/ha. When insufficient nitrogen (90 kg/ha) was applied at planting time, the yield was 23.9 t/ha and a significant increase resulted from nitrogen side dressings. Supplementary nitrogen increased the nitrogen content of the plant in all situations. The results confirm that the application of adequate nitrogen at planting is a sound management practice.

## **ENVIRONMENTAL QUALITY**

### **Diquat residues in potato tubers**

A previously developed gas chromatographic method for the analysis of diquat (top-killer) in potato tubers was utilized to determine residue levels in a total of 36 duplicate treated and untreated samples in 1978. The results (residues ranging from 0.01 to 0.08 ppm for treatments of from 0.5 to 2.25 kg/ha with diquat) were consistent with and

verified trends established in the two preceding years of study. The simultaneous addition of chemical aging adjuvants did not noticeably affect residue uptake.

### **Acylalanine fungicides**

A gas chromatographic method was developed for the determination of a new class of acylalanine systemic fungicides in potato tubers. The fungicides Ridomil at 0.3 and 0.25 kg/ha, CHEV 26745 at 0.14 kg/ha, and CHEV 20615 at 0.14 kg/ha gave good results against late blight. At these levels no residues greater than 0.01 ppm were detectable in the tubers.

### **Potato glycoalkaloid analysis**

A gas chromatographic method was developed for the analysis of potato glycoalkaloids by direct determination of the alkaloid components isolated by hydrolysis with HCl-ethanol. Recoveries of solanidine from potato tubers and foliage fortified with solanine over a range equivalent to one-half to five times the glycoalkaloid originally present averaged greater than 95%, and the lower limit of sensitivity was 0.25 mg/100 g using a nitrogen-phosphorus specific detector. A means of distinguishing between demissidine and solanidine by formation of their respective 3-trifluoroacetates with trifluoroacetic anhydride was also developed.

### **Thiabendazole residues on potato tubers**

Thiabendazole is a fungicide that has been shown to control the major potato fungal storage diseases. An amount of 3 ppm is considered adequate for this control. In 1979, 34 duplicate samples from nine different farmers were analyzed for surface residues of thiabendazole. The residue quantities ranged from 0.52 to 8.93 ppm for unwashed tubers. Although methods of application and rates undoubtedly vary from place to place, odd-shaped varieties like Netted Gem appear to obtain comparatively less efficient coverage from the thiabendazole spray.

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## INTRODUCTION

Les recherches effectuées à cette station sont appliquées aux problèmes agricoles de l'est du Canada et particulièrement du Québec. Elles sont axées sur les productions animales, notamment les bovins, les moutons et les porcs et sur les productions fourragères. La station est le noyau de la recherche zootechnique au Québec et à cet effet, plusieurs chercheurs collaborent avec des chercheurs d'autres centres de recherches. Ce rapport résume quelques expériences terminées au cours des années 1978 et 1979.

Le personnel scientifique a augmenté pendant cette période. En effet, mademoiselle Anne-Marie B. de Passillé et monsieur Serge Pommier se sont joints à l'équipe.

On peut obtenir de plus amples renseignements directement des chercheurs en écrivant à: Station de recherches, Agriculture Canada, C.P. 90, Lennoxville (Québec) J1M 1Z3.

Paul Flipot  
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## ZOOTECHE

### Bovins laitiers

*L'influence de la qualité du foin et du niveau de protéines végétales sur le développement de la génisse laitière.* On a utilisé 60 génisses croisées de type Holstein pendant 17 semaines afin d'étudier l'effet de servir deux types de foin et d'incorporer dans les aliments d'allaitement deux niveaux de protéines végétales et deux types de lactosérum sur la croissance des génisses. Les aliments d'allaitement servis avaient un minimum de 23% de protéine et de 11% de gras. On substituait dans ces aliments 45 et 65% de la protéine du lait par de la protéine végétale provenant d'un concentré de soya. On y incorporait du lactosérum séché selon le procédé de pulvérisation ou cylindrique. Les génisses recevaient une moulée dosant 20% de protéine. La consommation était limitée à 2,25 kg/jour. Le foin de mil et celui de mil et trèfle dosaient respectivement 7,9 et 15,7% de protéine et étaient servis à libre choix. Les génisses ont été achetées à un encan public. Elles étaient âgées de 2 à 4 jours environ et pesaient en moyenne 41,2 kg.

Durant la période d'alimentation lactée, les 25 premières semaines, le gain quotidien moyen, la consommation totale d'aliments d'allaitement, de moulée, de foin, de matière sèche et de protéine ont été de 0,37, 11,6, 14,1, 5,5, 28,6 et 6,1 kg respectivement. Les génisses recevant du lactosérum séché par pulvérisation ont consommé significativement moins de moulée (24,6%) que celles nourries au lactosérum séché par procédé cylindrique. Leur gain a été réduit aussi de 16,5%.

Au cours des 10 premières semaines, les génisses alimentées au foin de mil et trèfle ont consommé 55,5% plus de foin que celles nourries au foin de mil. Cette différence est significative à  $P < 0,01$  mais leur gain quotidien et leur consommation totale de matière sèche et de protéine ont été supérieures de 6,5, 7,5 et 14% respectivement mais ne furent pas significatives. La substitution dans les aliments d'allaitement de 45 et 65% de la protéine du lait par la protéine végétale n'a pas eu d'effet sur la croissance. Il y a seulement l'effet observé à 5 semaines du lactosérum qui se manifeste encore dans le même sens. La réduction de croissance a été de 9,3% et la consommation de moulée de 10,5%.

À la fin de la période expérimentale, le gain quotidien moyen, la consommation totale de moulée, de foin, de matière sèche et de protéine ont été de 0,75, 194,4, 116,5, 286,5 et 49,5 kg respectivement. L'incorporation dans les aliments d'allaitement de 45 et 65% de protéine végétale et de lactosérum séché selon le procédé de pulvérisation ou cylindrique n'a pas affecté significativement la croissance des génisses. L'alimentation du foin de mil et trèfle au lieu du foin de mil avec 2,25 kg de moulée quotidiennement a augmenté le gain quotidien des génisses de 8,9%. La consommation totale de foin, de matière sèche et de protéine a été supérieure de 19,6, 5,5 et 20,5% respectivement. Toutes ces différences ne furent pas significatives à  $P < 0,05$ .

*Veaux lourds au lait ou «veaux de grains».* La réduction du coût de l'alimentation dans la production de veaux lourds produisant une

carcasse de 90 kg doit être une préoccupation constante de la part du producteur qui désire améliorer la rentabilité de cet élevage. Au Québec, la production de veaux lourds est à ses tous débuts et les critères, permettant de choisir entre les aliments d'allaitement ou le grain pour produire des veaux lourds, ne sont pas suffisamment connus.

Avec 60 veaux mâles noir et blanc, de type Holstein, achetés dans un encan public au poids d'environ 45,5 kg, on a comparé quatre régimes alimentaires. Il y avait deux groupes exclusivement aux aliments d'allaitement et deux groupes aux aliments d'allaitement durant les cinq premières semaines complémentés avec une moulée dosant 16% de protéine brute et servis dès le début de l'élevage. La durée de l'élevage, le gain quotidien, la consommation totale d'aliments tels que servis et l'efficacité alimentaire des veaux nourris au lait ou au grain ont été respectivement de 127 et 145 jours, 0,87 et 0,83 kg, 185 et 400 kg, 1,65 et 3,31. Ces résultats ont confirmé ce que nous avons observé antérieurement, à savoir, qu'il faut en général 3 semaines de plus aux veaux de grains pour produire le même poids de carcasse froide sans peau (90 kg) que les veaux de lait.

Au niveau de certains paramètres de santé comme pour la diarrhée, les troubles respiratoires et le taux de mortalité, il n'y a pas eu de différence significative entre les veaux de lait ou de grains.

La qualité des carcasses, évaluées selon le système de classification officielle d'Agriculture Canada, a été légèrement influencée par le type d'alimentation. Il y a eu 50 carcasses d'évaluées dont aucune ne s'est classée A, 4B, 33C et 13D. Dans la catégorie C, 61% des carcasses provenaient des veaux de lait. Cependant, le système actuel de classification est en voie de révision et le nouveau système va probablement atténuer cette différence.

Le coût partiel de production, comprenant l'alimentation et les médicaments, a été pour les veaux de lait de \$210 et \$19 tandis que le coût pour les veaux de grains a été de \$83 et \$17.

*Quand récolter le maïs fourrager?* Pour 2 années consécutives, on a récolté du maïs fourrager à cinq différentes dates entre le début de septembre et la fin d'octobre. L'ensilage de ces maïs a été servi à des vaches laitières dans le but de déterminer l'effet du gel avant la récolte sur la digestibilité de 10

nutriments. Les résultats ont démontré que la digestibilité de la matière sèche et de l'énergie atteignait un maximum avant la première gelée mortelle. Les gelées subséquentes ont accentué la diminution de la digestibilité. La consommation volontaire a aussi été influencée par la date de la récolte. La consommation volontaire de matière sèche digestible est maximale avant la première gelée ou tôt après la deuxième gelée. La production laitière, la plus élevée, a été observée lorsque l'ensilage avait été récolté après la deuxième gelée soit de 23,8 kg comparativement à 12,9 kg par vache par jour lorsque l'ensilage était récolté après cinq gelées à la fin d'octobre. À la suite de ces résultats, il est permis de conclure qu'il serait recommandable de récolter le maïs fourrager au plus tard après la deuxième gelée mortelle soit au niveau de 30 à 34% de matière sèche. Le gel influence la composition et la valeur alimentaire de l'ensilage de maïs. Les tables de composition généralement utilisées surestiment la valeur énergétique des ensilages récoltés après la gelée mortelle et, par conséquent, ne devraient pas être utilisées pour des ensilages récoltés au Québec. Une équation multiple a été construite. Celle-ci explique 96% de la variation de l'énergie nette pour le lait. Les composantes de l'ensilage nécessaires pour cette formule sont le pourcentage de calcium, de magnésium, de potassium et de lignine insoluble dans les détergents acides.

## **Bovins de boucherie**

*Influence du vêlage et de la gémellité des taures d'embouche sur l'économie de production et la qualité des carcasses.* On s'est servi de 140 génisses croisées Hereford × Holstein, non utilisables pour la réforme du troupeau, pour démontrer s'il est avantageux ou non, au point de vue rentabilité, qualité de carcasse et volume de production, de les faire vêler avant de les abattre. Le travail a nécessité deux régimes, qui se sont poursuivis durant 2 années consécutives. Pour les besoins de la cause, on les a divisées en quatre groupes d'après les traitements. Les génisses du groupe I servant de témoin ne vêlaient pas et étaient vendues à mesure qu'elles atteignaient le fini exigé par le système canadien de classement du boeuf. Celles du groupe II ont vêlé et nourri leurs veaux durant 60 jours à la première expérience et 15 jours à la deuxième, puis ont été abattues immédiatement. Quant à leurs veaux, ils ont été abattus

au sevrage, avec leur mère, à la première expérience et ont été développés jusqu'au poids vif de 90 kg à la deuxième. Les génisses du groupe III et IV ont vêlé comme celles du groupe II et ont été engraisées après le sevrage, lorsque les tests à l'ultrason nous indiquaient qu'elles ne possédaient pas assez de fini pour répondre aux exigences de la catégorie A du système de classement du boeuf du Canada. Elles étaient alors abattues. Quant à celles du groupe IV, elles recevaient en plus, une injection de P.M.S.G. pour favoriser la gémellité. On a gardé ces génisses en stabulation libre dans une étable ouverte du côté sud-est. Elles y ont vêlé sur la fumière, en novembre, décembre, janvier et février, à l'âge de 20 à 22 mois. À la première expérience, elles ont consommé de l'ensilage de maïs et 2,25 kg de moulée, à laquelle on a ajouté 0,9 kg d'orge roulée par tête et par jour. À la deuxième expérience, on leur a servi seulement de l'ensilage de luzerne récoltée en octobre.

Des résultats obtenus des deux expériences, il découle:

(a) qu'on peut produire une viande d'excellente qualité à partir de génisses de surplus, croisées Hereford × Holstein, que l'on fait vêler avant de les abattre;

(b) qu'il n'est pas rentable de garder ces génisses plus longtemps qu'il ne faut pour leur permettre de se rétablir après leur vêlage;

(c) qu'on pourrait au moins doubler la quantité de viande de ces génisses, si on élevait leur descendant jusqu'au poids du marché du bouvillon;

(d) qu'on accroîtrait la productivité des génisses, si l'on pouvait leur faire produire des jumeaux.

*Influence du taux de semis et de la fertilisation azotée du maïs fourrager sur les performances des bouvillons.* Dans cette expérience, nous avons comparé deux populations de maïs (86 000 vs 129 000 plants/ha) fertilisées à deux niveaux d'azote (145 ou 195 kg/ha). Nous avons utilisé 64 bouvillons pour comparer les effets de la population et de la fertilisation. La moitié des bouvillons recevait 500 g de tourteau de soya par jour et par tête. La durée de l'expérience a été de 92 et de 112 jours pour la 1<sup>re</sup> et 2<sup>e</sup> années respectivement. Nous avons noté une interaction significative entre les doses azotées et les années ainsi qu'entre l'addition de tourteau de soya et les années. La fertilisation et le taux de semis n'ont pas eu d'effet significatif sur le gain des

bouvillons. Lors de la répétition, nous avons observé un meilleur taux de gain pour les bouvillons alimentés avec le maïs qui avait été fertilisé avec 195 kg/ha d'azote. Dans les deux études, l'addition de tourteau de soya a eu un effet hautement positif sur les taux de gain des bouvillons.

*Concentration de la progestérone, des oestrogènes et du cortisol dans le plasma des vaches ayant donné naissance à des jumeaux ou ayant eu des rétentions placentaires.* Nous avons étudié pendant la période péripartum les taux de stéroïdes plasmatiques associés aux naissances simples normales (V.U.N.) ou avec rétention placentaire (V.R.P.) et aux naissances gémellaires (V.G.). Chez les témoins (V.U.N.), la progestérone baissa régulièrement de 5,5 ng jusqu'à moins de 1 ng/mL au jour du vêlage. Pendant les 2 jours précédents et au jour du vêlage, elle était significativement plus élevée dans les groupes avec rétention placentaire (V.R.P.) et naissances gémellaires (V.G.). Les profils de l'oestrone et de l'oestradiol-17 $\beta$  étaient semblables dans les groupes V.U.N. et V.R.P. jusqu'au lendemain du vêlage. Chez les femelles ayant donné naissance à des jumeaux, les taux d'oestrogènes étaient beaucoup plus élevés. Pendant la période postpartum, la chute des oestrogènes était beaucoup plus lente dans les groupes V.R.P. et V.G. que dans le groupe témoin (V.U.N.).

Le cortisol, chez le groupe témoin s'est élevé graduellement jusqu'au moment du vêlage puis s'est abaissé graduellement jusqu'au niveau original. Pour le groupe V.R.P., le cortisol n'a pas varié de façon importante avant ou après le vêlage.

Ces résultats suggèrent donc que la rétention placentaire n'est pas liée aux taux plasmatiques du cortisol, mais qu'elle pourrait être associée à un taux de progestérone trop élevé le jour du vêlage et que la baisse lente des oestrogènes ne serait que le résultat du détachement incomplet du placenta.

## Moutons

*Mesures corporelles et de carcasses du mouton D.L.S. et de son croisement avec le Finnish-Landrace abattu à trois poids.* Les mesures corporelles avant abattage et les caractéristiques des carcasses de 24 moutons D.L.S. et de 24 moutons = Finn = D.L.S. ont été comparées à trois poids d'abattage soit: 22,7, 32,2 et 40,7 kg. La longueur du corps, la ceinture du coeur et la circonférence

de la ronde entre les deux groupes d'animaux étaient semblables pour les trois poids d'abatage. Les animaux plus lourds avaient un rendement de carcasse supérieur, un pourcentage de jarret et d'épaule inférieur et un pourcentage de coupe de la longe légèrement supérieur aux animaux plus légers. L'épaisseur de gras à la 12<sup>e</sup> côte ainsi que son contenu en gras augmentaient avec le poids d'abatage.

Les carcasses issues du croisement Finn × D.L.S. ne sont pas inférieures au D.L.S. pur-sang et sont facilement acceptées par le consommateur.

## Porcs

*Durée de la mise-bas, survie et croissance des porcelets Landrace en fonction de l'ordre de naissance et de tétée.* On a étudié la durée de la mise-bas de 19 truies Landrace ainsi que l'effet de l'ordre de naissance et de tétée sur les performances avant sevrage des porcelets. Soixante-quatorze pourcent des mises-bas ont eu lieu en dedans de 3 h, 10% entre 3 et 4 h et 16% entre 4 et 5 h. La moyenne et le mode des durées de mise-bas étaient respectivement de  $140,5 \pm 14$  et de 13 min ou 15,7 et 8 min par porcelet. La durée des mises-bas était plus courte pour les portées moyennes comparativement aux grosses et petites portées.

Les porcelets premiers-nés étaient les plus lourds. La corrélation entre l'ordre de naissance et le poids à la naissance était de 0,22. La survie des porcelets était très influencée par l'ordre et le poids à la naissance. Indépendamment du poids à la naissance les porcelets les plus agressifs et dominants étaient les mamelles les plus antérieures. La croissance de ceux-ci était légèrement améliorée.

## PHYTOTECHE

### Plantes fourragères

*La motoneige et la persistance des plantes fourragères.* Au cours de trois hivers consécutifs, on a étudié l'effet des pistes de motoneige sur le rendement et l'analyse botanique des plantes fourragères dans le sud du Québec. À chaque printemps, on mesurait par échantillonnage, le rendement et la composition botanique de la piste et on les comparait aux données obtenues à côté de la piste.

Sur nos parcelles d'expérimentation on a constaté que dans l'ensemble, la motoneige n'a pas affecté significativement les rendements des fourrages, la réduction n'a été que

de 7%. Nos vérifications ont également démontré qu'il y a eu réduction appréciable du pourcentage des légumineuses. La proportion en luzerne a diminué significativement. Les mauvaises herbes, en bonnes compétitrices, ont profité de cette situation en augmentant leur population de 28%. Par contre, les graminées se sont, en général, moquées de la motoneige, n'ayant subi des réductions que de 8%.

Nos travaux suggèrent que le tassement de la couche de neige risque de causer certains dommages aux prairies de légumineuses. Une parfaite harmonie dans les décisions entre les cultivateurs et les clubs de motoneige quant au choix de l'emplacement des pistes réduirait de beaucoup les risques de pertes inutiles.

*Effet des cultivars sur l'ingestion volontaire du mil, par les moutons.* Dans un effort pour évaluer la qualité de cinq cultivars de mil, on a conduit une série d'expériences où l'on mesurait les différences d'ingestion par les moutons. On a récolté, au stade de floraison, trois cultivars tardifs: Climax, Bounty et Milton ainsi que deux hâtifs: Clair et Champ. Ils étaient tous très productifs et recommandés aux cultivateurs.

On a récolté, séché et haché le fourrage que l'on a servi à des béliers antenais lors d'une série d'expériences d'une durée de 2 semaines chacune. Quinze moutons ont été alimentés de chacun des cultivars. Le dispositif carré latin  $5 \times 5$  fut adopté pour ces expériences. On a également récolté les mêmes cultivars à la même date. Les variétés tardives avaient alors atteint le stade de pleine floraison.

Champ, un cultivar hâtif, se classa premier dans trois essais sur quatre et deuxième lors du quatrième essai.

Lorsqu'on corrigea les valeurs d'ingestion volontaire en tenant compte du poids de l'animal, Champ arriva encore en premier ou en deuxième rang dans tous les essais. À l'opposé, le cultivar semi-tardif se classa dernier dans trois essais sur quatre et avant-dernier dans le quatrième test.

Par anticipation, on serait tenté de croire que la différence draconienne du classement des cultivars pourrait s'expliquer par le différent degré de maturité atteint par les cultivars en fleurs et les autres coupés à la même date mais un stade plus avancé. Ceci ne fut pas le cas. L'ingestion des cultivars hâtifs s'est avérée plus élevée que les autres dans les deux régimes de fauche.

La repousse des cultivars de mil était très verte, feuillue et ne contenait pas de tiges grossières. L'ingestion de ce fourrage a été élevée et on a décelé moins de différences significatives entre les cultivars. Cependant, la tendance notée lors de la première coupe fut renversée et l'ingestion des cultivars tardifs a été plus grande que celle des hâtifs. Climax, qui avait affiché la plus basse performance lors de la première récolte, a été ingéré à un degré significativement plus élevé que tous les autres cultivars excepté Bounty, tandis que Champ, bon premier au point de vue ingestion lors de la première coupe, arriva dernier. En moyenne, l'ingestion quotidienne, corrigée par rapport au poids des moutons, s'est chiffrée à 92 g/kg (poids<sup>0,75</sup>) comparé à 66, 58 g respectivement lors de la première coupe, les 2 années.

La digestibilité «in vivo» des mêmes fourrages coupés à floraison a été évaluée lors d'une autre expérience où l'on utilisait des moutons. On n'a observé aucune différence significative de digestibilité entre les cultivars. Les cultivars hâtifs ont quand même manifesté une légère tendance vers une plus grande digestibilité que les autres.

Les différences d'ingestion des cultivars peuvent donc s'expliquer par leurs caractéristiques physiques et chimiques et non par leur digestibilité.

## Sol

*En sols acides, les plantes meurent d'intoxication.* On a observé que le chaulage des sols acides augmentait le rendement des cultures. De quelle façon et en vertu de quel principe ou mécanisme? On a tenté de trouver la réponse à la station de recherches à Lennoxville.

Nous avons expérimenté à plusieurs endroits des Cantons-de-l'Est et de la Plaine de Montréal. Nous avons utilisé des légumineuses, des graminées et des céréales. Nous avons dosé les éléments nutritifs contenus dans les plantes et les sols, afin de voir comment un changement de pH du sol, par l'application de chaux, affectait ces teneurs en minéraux.

Une observation s'est clairement dégagée de la multitude de données expérimentales recueillies sur ces sols du Québec: on chaulait surtout à cause du manganèse et de l'aluminium.

On sait que beaucoup de loams et de sables acides (pH 5,0) contiennent des quantités excessives d'aluminium et de manganèse. Les plantes qui y croissent en absorbent de grandes quantités et s'intoxiquent.

On sait par exemple, qu'une teneur supérieure, 400 ppm (parties par million), cause une intoxication manganique grave chez la luzerne. Or, on a constaté que de la luzerne cultivée dans un sol dont le pH était 5,0, dosait plus de 1000 ppm de manganèse (Mn). On a aussi montré qu'il faut accroître le pH du sol au-delà de 6,5 pour abaisser la teneur de la luzerne en bas du seuil de toxicité. Il va sans dire qu'il ne faut surtout pas appliquer de manganèse.

Dans notre expérience, nous avons souvent eu recours à un chaulage massif pour abaisser la teneur en manganèse et en aluminium du sol, atteignant ainsi des pH de 6,8 à 7,5. On a alors provoqué une carence de bore et de magnésium. Il nous a fallu combattre cet effet nocif par l'application de bore à 3 kg/ha et de magnésium à 50 kg/ha.

Les conclusions qui ressortent de cette série d'expériences exécutées depuis toutes ces années, sont les suivantes: l'action de la chaux est bénéfique parce que la chaux prévient l'intoxication des végétaux par le manganèse et l'aluminium et parce qu'elle assure aux plantes une meilleure alimentation azotée et phosphatée. Il en est résulté des récoltes plus abondantes et de qualité supérieure. D'un autre côté, trop accroître le pH du sol peut provoquer des carences de bore, de magnésium et de phosphore.

Dans le chaulage des sols, comme dans toute autre pratique agronomique, il faut éviter l'excès et bien s'assurer de respecter la nature du sol et la physiologie des plantes. Avec un peu d'intelligence et de technique, on prendra avantage des effets du changement de pH des sols sur la croissance des végétaux, sans cependant chauler à l'aveuglette.

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### Départs

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## INTRODUCTION

La station de Sainte-Foy concentre ses recherches sur les divers aspects de la production, de l'amélioration, de la survie et de la protection des plantes fourragères et des céréales, ainsi que sur les sols. On poursuit également des recherches sur les plantes horticoles, les ovins et les bovins laitiers aux fermes expérimentales de La Pocatière et de Normandin. Ce rapport renferme des résultats de recherches obtenus durant l'année 1979.

On peut obtenir des renseignements plus complets en s'adressant à: Station de recherches, Agriculture Canada, 2560 boulevard Hochelaga, Sainte-Foy (Québec) G1V 2J6.

S. J. Bourget  
Directeur

### LES PLANTES

#### Les graminées fourragères

Une étude qui dure maintenant depuis 3 ans démontre clairement qu'il est possible d'utiliser toute la saison de croissance pour augmenter la production de la fléole des prés, *Phleum pratense* L., sous un climat froid. On a en effet obtenu un rendement total annuel de 8000 kg de matière sèche à l'hectare à Normandin, Lac-Saint-Jean, à tous les ans en prélevant deux coupes de fléole: une première au stade épiaison et une deuxième dans la troisième semaine de septembre. La deuxième coupe en septembre ne semble aucunement affecter la survie de la fléole ou sa production lors de sa première coupe de l'année suivante.

Toujours à Normandin, l'application de fertilisant azoté à sept taux différents variant entre 0 et 224 kg/ha sur trois cultivars de la fléole des prés a permis d'obtenir une augmentation graduelle du rendement en matière sèche, qui est passé de 4084 kg/ha à 6415 kg/ha en moyenne pour les trois cultivars. Climax a été le cultivar le plus productif avec un rendement moyen de 6225 kg/ha et Clair a été le moins productif ne donnant en moyenne que 5290 kg/ha.

*Genres de semis.* Une comparaison entre les rendements de différents cultivars de la luzerne (*Medicago sativa* L.), du trèfle rouge (*Trifolium pratense* L.) et de la fléole des prés selon divers modes et taux de semis, en semis purs et en mélange, indique que la luzerne s'est avérée de beaucoup supérieure au trèfle rouge et à la fléole. Le semis en rangées a permis d'obtenir des rendements plus élevés que les semis à la volée. Durant l'année d'établissement, le taux de semis n'a eu aucun effet sur le rendement de la fléole alors qu'une

augmentation du taux de semis jusqu'à 12 kg/ha a permis d'accroître le rendement de la luzerne à Saint-Augustin.

Une autre étude pour comparer le rendement de la luzerne, du trèfle rouge et de la fléole en semis pur et en mélanges à La Pocatière et à Normandin rapporte un rendement plus élevé pour la luzerne que pour le trèfle rouge. Toutefois, la fléole en semis pur recevant N à 150 kg/ha a fourni un rendement légèrement plus élevé que la luzerne. À La Pocatière et à Normandin respectivement, la luzerne en semis pur a donné des rendements de 6785 et de 4564 kg/ha, le trèfle rouge en semis pur de 3747 et de 3595 kg/ha, la fléole en semis pur de 6945 et de 5188 kg/ha, le mélange luzerne-fléole de 6785 et de 5053 kg/ha et le mélange trèfle rouge-fléole de 4837 et de 4871 kg/ha.

*Inoculation.* Le rendement du brome (*Bromus inermis* Leyss.) dans des parcelles inoculées artificiellement en début de végétation par le *Dreschlera bromi* (Died.) Shoem., a été, en moyenne, de 7663 kg de matière sèche par hectare. Toutefois, le rendement du brome en parcelles soumises à l'infection naturelle a été de 8368 kg/ha, pour une différence de rendement de 8,4%. Au moment de la récolte des deux coupes, le degré d'infection globale était identique dans les deux groupes de parcelles indiquant clairement qu'une dispersion hâtive de l'inoculum est plus dommageable qu'une infection (naturelle) tardive.

#### Les légumineuses fourragères

Les conditions hivernales des trois dernières années ont été favorables à la survivance de la luzerne à l'hiver au Québec, ce qui n'a pas permis d'effectuer une sélection intense pour

ce facteur. Toutefois, deux plants, le Saranac et l'Iroquois, sélectionnés à cette fin ont montré dans des essais à Charlottetown (Î.-P.-É.) des pourcentages de survie de 52 et 49 comparativement à 29 et 8 respectivement pour les cultivars Iroquois et Saranac d'origine. Ces cultivars sont évalués également au Québec et l'un des deux a jusqu'ici donné des rendements d'environ 5% supérieurs aux cultivars Saranac et Iroquois.

*Maladies.* L'évaluation du degré de pourriture racinaire chez une population de plants de luzerne sélectionnée comparativement à la population d'origine a révélé un degré de pourriture moindre chez la population sélectionnée après seulement une année aux champs. La différence fut beaucoup plus marquée pour le site où le degré générale de pourriture était plus élevé. Le rendement de la population sélectionnée fut également supérieur à celui de la population d'origine.

La descendance de plantes sélectionnées pour leur résistance à la tache leptosphaerulienne a montré une très légère augmentation de résistance à cette maladie. Le peu de progrès réalisé semble relié à la difficulté d'évaluer adéquatement le niveau de résistance. La sélection pour la résistance au nématode cécidogène a révélé une immense variation inter et intrafamiliale. Les meilleurs plants à l'intérieur de plusieurs familles ont été sélectionnés en vue de croisements avec du matériel adapté mais non résistant à ce nématode.

Les techniques développées lors de la sélection pour la résistance aux maladies a permis de mesurer l'effet des maladies sur la résistance au froid de la luzerne. C'est ainsi que l'on a constaté que le pourridié et le flétrissement fusariens rendent la luzerne plus sensible au gel. D'un autre côté, le gel a favorisé le développement de ces maladies.

Les luzernières sont, de façon générale, affectées par des pourritures racinaires. Les maladies du feuillage les plus importantes sont la tige noire (*Phoma medicaginis* Malbr. & Roum.), la tache leptosphaerulienne [*Leptosphaerulina briosiana* (Pall.) Graham & Luttrell] et la tache commune [*Pseudopeziza medicaginis* (Lib.) Sacc.]. Les pertes causées par les maladies et la mineuse virgule ont été évaluées à \$11 millions. Parallèlement à cet inventaire, une étude de la dynamique des maladies a indiqué que les périodes les plus propices à l'inventaire sont celles qui précèdent immédiatement les coupes.

*Nématodes.* Un inventaire nématologique effectué sur une période de 6 ans a révélé la présence de huit genres de nématodes phytoparasites associés à des cultures de plantes fourragères, dans 254 champs échantillonnés dans la province de Québec. Les nématodes *Pratylenchus* spp., *Meloidogyne* spp., *Helicotylenchus* spp., *Paratylenchus* spp. et *Heterodera* spp. étaient présents dans 88, 71, 66, 65 et 65% de tous les champs échantillonnés; les nématodes *Tylenchorhynchus* spp., *Macroposthonia* spp. et *Xiphinema* spp. dans une plus petite proportion des champs. Les populations du nématode des lésions de racines, *Pratylenchus* spp., étaient les plus denses dans les sols de luzerne (*Medicago sativa* L.), de trèfle rouge (*Trifolium pratense* L.), de lotier corniculé (*Lotus corniculatus* L.), de fléole des prés (*Phleum pratense* L.) et de brome (*Bromus inermis* Leyss.). Ces populations étaient plus denses dans les champs de fléole des prés et de trèfle rouge que dans ceux de luzerne. La densité de population du nématode des lésions de racines, *Pratylenchus*, et du nématode cécidogène, *Meloidogyne*, était plus grande dans les racines de trèfle rouge que dans celles de la fléole des prés et de la luzerne. Le nématode des kystes de racines, *Heterodera* spp., a été isolé surtout des racines de trèfle rouge. La densité de population moyenne du nématode «spiral», *Helicotylenchus* spp., était la plus grande dans les champs de fléole des prés.

Les récentes expériences effectuées avec la double symbiose chez la luzerne indique que les endomycorrhizes (*Glomus* spp.) ont augmenté de 19% le rendement des plantes nodulées avec le *Rhizobium meliloti*.

*Fixation d'azote.* Une méthode de différenciation immunologique des souches du *R. meliloti* a été mise au point en se servant des techniques modernes d'immunofluorescence indirecte par éclairage en lumière réfléchiée sur un microscope spécialement conçu pour cette fin. Cette méthode positive d'identification des souches nous a permis de recueillir des données sur les conditions qui affectent la nodulation et l'expression de la nitrogénase chez la luzerne. Il a été mis en évidence que le développement radiculaire et aérien des plantules de luzerne est fortement influencé par la présence simultanée d'azote et de soufre dans le milieu; le soufre améliore la nodulation tandis que l'azote favorise le développement radiculaire mais inhibe l'activité nodulaire. Il ne semble pas y avoir de lien génétique direct

entre l'activité du nitrate réductase chez le *R. meliloti* et son activité nitrogénasique en symbiose avec la luzerne car un mutant de phénotype déficient en nitrate réductase a retenu la même capacité d'infection et la même activité nitrogénasique que la souche mère, contrairement à ce qui a été proposé par d'autres chercheurs.

*Influence du climat.* Les résultats de 5 années de recherches dans les conditions du champ indiquent que l'endurcissement naturel de la luzerne (*Medicago media* Pers.) est lié à l'abaissement de la température et serait peu influencé par la photopériode. L'enregistrement de la température de l'air au niveau de la plante et au niveau du collet offrent à certains moments des différences assez marquées avec celui des stations de météorologie situées dans la région. Certaines des différences notées dans les observations de la température du sol au cours de l'hiver sont dues au fait que leur enregistrement n'est pas fait dans les mêmes conditions. Dans les périodes critiques où le gel pourrait être nocif pour la plante, il serait difficile d'expliquer la mortalité en se servant uniquement des données des stations de météorologie.

Il semble de plus en plus évident que la formation de la glace sur le sol gelé au début de l'hiver est plus préjudiciable à la survie de la luzerne que si la glace est formée au cours de l'hiver alors qu'une épaisse couche de neige recouvre le sol. On pourrait probablement trouver une explication dans le pouvoir isolant de la neige et la conductibilité de la glace.

*Physiologie de la résistance au froid.* Même s'il est reconnu que durant l'endurcissement au froid des plantes, il y a perte d'eau dans les tissus, des expériences montrent qu'une atmosphère presque saturée, 95 à 100% d'humidité relative, n'empêche pas la luzerne et le blé d'hiver (*Triticum aestivum* L.) de s'endurcir. Cependant, le stress du froid et celui de la sécheresse se conjuguent pour augmenter considérablement la teneur en proline des tissus. L'humidité de l'atmosphère ne semble pas modifier la teneur en sucres ni celle des acides gras, à l'exception du 18:2 et 18:3 qui augmentent lorsque l'humidité de l'air est élevée.

Peu de changements ont été observés dans les stérols au cours de l'endurcissement au froid du blé d'hiver.

Certaines protéines seraient formées durant l'endurcissement au froid du blé d'hiver. Dès le début du désendurcissement, l'activité des

protéases augmente avec le résultat que certaines protéines disparaissent. Cette approche permettrait de caractériser ces protéines liées à l'acquisition de la résistance au gel.

La fléole des prés (*Phleum pratense* L.) s'endurcit légèrement moins au gel ( $TL_{50}$  ou température léthale pour 50% des plantes) que la luzerne et le blé d'hiver et prend deux fois plus de temps pour atteindre le maximum d'endurcissement à  $1,5 \pm 0,5^\circ\text{C}$ . L'accumulation de la proline dans les différents organes de la plante offre une forte corrélation de type quadratique avec la  $TL_{50}$ .

## Les céréales

*Biologie et écologie des mauvaises herbes.* Un inventaire des mauvaises herbes présentes dans les cultures céréalières dans la région de Québec a débuté en 1978 et s'est poursuivi en 1979. Les résultats préliminaires indiquent que le chiendent est très répandu dans les champs de céréales, que les graminées annuelles sont présentes sur les retours de maïs et que les mauvaises herbes annuelles à feuilles larges sont dominantes dans les deux cas.

Même si environ 20 espèces de mauvaises herbes caractérisent les cultures céréalières, l'utilisation des herbicides reste faible.

Une étude sur le dynamisme des populations de mauvaises herbes à la suite d'applications répétées d'herbicides révèle qu'après la suspension des traitements avec les herbicides, il y a une augmentation de la diversité floristique et une stabilisation du chiendent à un niveau approchant celui des parcelles témoins. Donc la succession secondaire tend vers le même stade après l'arrêt des interventions, sauf si l'espèce ou les espèces dominantes ont été détruites.

L'étude de l'influence du régime hydrique sur le rendement des céréales en fonction de deux dates de semis confirme que, sauf pour l'orge, la déficience en eau lorsque la température est basse est moins néfaste que sous une température élevée. Avec des céréales semées tardivement l'irrigation est nécessaire pour obtenir des rendements semblables à ceux des céréales semées tôt. Le régime hydrique semble plus important que la température du sol pour expliquer les variations de rendement.

L'effet de trois taux de semis effectués à la volée indique qu'à 50 kg/ha les rendements en grains des céréales sont très faibles et que ce taux favorise une forte infestation par les mauvaises herbes. À 200 kg/ha, les rende-

ments semblent très satisfaisantes tandis qu'à 100 kg/ha, le taux de semis commercial, les rendements semblent inférieurs à ceux obtenus avec le même taux pour un semis en rangée.

*Le blé.* La lignée Laval 19 est maintenant homologuée sous le même nom. Ce blé d'alimentation trouvera sûrement sa place chez les producteurs du Québec.

L'évaluation et la lutte aux dommages directs et indirects causés au blé par le BYDV (barley yellow dwarf virus) se sont poursuivies. En effet, l'existence d'une phase secondaire de susceptibilité au début du stade de l'élongation chez le blé est confirmé. Ceci occasionne des pertes importantes de rendement, allant jusqu'à 30%, accompagnées de très peu de symptômes. Des parents assez résistants au BYDV: SH7575, SH7580, Rongotea, Pel 72390, Pel 10054-65, U.C.1, U.C.7, U.C.8, peuvent servir de base à un programme de croisements.

Une étude sur la contamination des grains de blé par les *Fusarium* spp. démontre que les lignées de blé vitreux panifiables, Neepawa, BW20 et Sinton sont moins réceptives à la contamination que les lignées de blé farineux d'alimentation animale comme l'Opal, le Laval 19 et le Concorde.

*L'orge.* Soixante-seize nouveaux croisements réalisés en 1979 viennent s'ajouter aux 134 croisements déjà en ségrégation. Des 3000 lignées en évaluation en 1979, plus de 150 ont un rendement égal ou supérieur au Laurier avec une paille améliorée. Il se caractérise généralement par une maturité de 1 ou 2 jours plus tardive que le Laurier.

L'orge Midas (CI 13840) possède un type de résistance différent de l'YD<sub>2</sub> quoique l'YD<sub>2</sub> soit beaucoup supérieur. Le cultivar Ariana est extrêmement susceptible. La résistance au BYDV de l'orge augmente plus vite que celle de l'avoine et du blé mesure que la plante vieillit au cours de la saison.

Le fongicide «furavax» a établi sa supériorité sur neuf autres traitements contre le charbon nu (*Ustilago nuda*) avec une répression presque complète.

*L'avoine.* Quatre-vingt-quatorze nouveaux croisements réalisés en 1979 viennent s'ajouter aux 193 déjà en ségrégation. Plus de 400 lignées sur 3700 lignées évaluées en 1979 ont obtenu un rendement égal ou supérieur au Laurent et au Lamar. Les lignées ont une maturité intermédiaire entre les deux témoins

et leur paille est également plus résistante à la verse.

La lignée AA68-75 (CI500 × QO62.5) et ses descendants sont nettement plus résistants que toute autre avoine au BYDV. Quelque 200 lignées d'avoine «sterilis» sur les 5000 étudiées sont résistantes au BYDV.

La lignée CI3928, identifiée comme source de résistance à la tache septorienne et à la jaunisse nanisante, a été utilisée comme parent dans deux croisements pour transférer la résistance dans des lignées cultivées.

## LES SOLS

### Fertilité

*Engrais minéraux.* Au champ, une expérience portant sur l'effet de trois doses de phosphore, de potassium et de soufre sur les rendements de la luzerne et la survie de cette légumineuse à l'hiver s'est poursuivie pour une deuxième année. Il n'y a pas eu de dégâts dans les parcelles dûs à l'hiver 1978-1979. Trois coupes de luzerne ont été prises pendant l'été 1979. Cependant il n'y a pas eu de différence significative entre les divers traitements. La moyenne des rendements totaux pour les trois coupes a varié entre 6570 et 7960 kg/ha. Dans plusieurs cas, cependant, de grandes différences ont été observées entre les répétitions d'un même traitement. Ces différences ont atteint jusque 3200 kg/ha et elles sont probablement attribuables à un manque d'homogénéité du sol. Les parcelles sont établies sur le sol Saint-André, un loam sablo-graveleux.

En serre, une étude a été faite sur l'effet de quatre doses de 10-10-10 sur la croissance des tiges et des racines de mil semé sur deux types de sol, les sols Saint-Pacôme et Kamouraska. Des doses croissantes d'engrais chimiques ont entraîné des augmentations de rendement pour trois coupes tant pour les tiges que pour les racines sur les deux types de sol. De plus, les rendements des racines ont toujours été supérieurs à ceux des tiges.

*Complexe échangeable.* Antérieurement, il avait été démontré que dans les sols gleysoliques riches en argile, la contribution de l'argile au complexe échangeable était de loin supérieure à celle de la matière organique. Une analyse minéralogique détaillée et fondée sur plusieurs techniques, diffraction des rayons X, méthodes chimiques, propriétés d'échange et de surface, a permis d'établir de

très bonnes corrélations ( $> 0,870$ ,  $n = 31$ ) entre les pourcentages des divers minéraux et des matériaux amorphes présents et diverses caractéristiques de la fraction argileuse et du sol total. Les analyses minéralogiques ont également permis de montrer une évolution plus poussée des sols gleysoliques dans le sud-ouest du Québec que dans les régions de Québec et du Lac St-Jean.

### Pédogénèse

*Sols sableux des basses-terres.* Dix profils à texture sableuse, représentant les principales séries développées sur matériaux grossiers d'origine éolienne ou deltaïque, ont été échantillonnés dans les basses-terres du Saint-Laurent. Suivant les critères de classification, sept profils appartiennent à l'ordre podzolique, tandis que les trois autres, moins riches en sesquioxydes combinés à la matière organique, appartiennent à l'ordre brunisolique. Les pH des horizons de surface sont bas dans les sols vierges, jusqu'à 3,05, mais atteignent jusqu'à 6,5 dans les sols cultivés par suite des additions de chaux. La teneur en argile de ces sols est inférieure à 10% et c'est donc principalement la matière organique qui est responsable de la capacité d'échange. Les teneurs en C organique diminuent avec la profondeur et varient entre 7,2 et 0% tandis que les valeurs de la C.E.C. varient de 23,6 à 0,11 meq/100 g. Dans la fraction fine de ces sols, les pourcentages de smectite varient de 15 à 25% et ceux de vermiculite se situent entre 5 et 10%.

L'analyse micromorphologique d'un profil dans la région de Saint-Albert a permis de constater que les produits de l'altération podzolique, matière organique, sesquioxydes de fer et d'aluminium, ainsi que de la silice avaient un fort pouvoir de cimentation des grains.

*Aluminium interfoliaire et matériaux amorphes.* Les hydroxypolymères d'aluminium et les matériaux amorphes ont été extraits de la fraction argileuse des horizons B podzoliques de quatre profils des Appalaches et de quatre autres des Laurentides. La solution de citrate de Na a extrait entre 2,0 et 14,7% de  $Al_2O_3$  dans les sols des Laurentides, et entre 1,0 et 2,5% de  $Al_2O_3$  dans les sols des Appalaches. Cependant, l'extrait obtenu pour les sols des Appalaches contenait aussi entre 2,0 et 7,5% de  $SiO_2$ . La solution de NaOH bouillant a extrait de 9,3 à 30,0% de  $Al_2O_3 + SiO_2$  dans les sols des Laurentides, tandis

qu'elle n'a extrait que de 2,2 à 4,1% de  $Al_2O_3 + SiO_2$  dans les sols des Appalaches.

Ces diverses extractions ont modifié de la façon suivante les valeurs de capacité d'échange cationique et de surface spécifique dans les divers sols. Après le traitement au citrate, la C.E.C. de l'argile des sols des Laurentides diminuait de 29 à 64% alors que la So a augmenté jusqu'à 34%. Pour l'argile des sols Appalachiens, la C.E.C. augmentait de 3 à 23% mais il y avait peu de variation dans la So. Après un traitement au NaOH, dans les sols Laurentiens, il y avait diminution de 46 à 79% de la C.E.C. et des augmentations de surface atteignant 16%. Pour les sols Appalachiens, il n'y avait pas d'effet sur la C.E.C., mais des augmentations de surface atteignant 28%.

Ces études montrent une forte variation dans la nature des matériaux amorphes dans les deux groupes de sols et que la sélectivité des méthodes proposées pour effectuer les extractions ne semble pas aussi spécifiques qu'elles le devraient.

*Drainage et propriétés physiques.* Cette étude a porté sur la caractérisation des différences existant entre quatre séries de sols drainés souterrainement depuis 60 ans ou moins et leurs homologues drainés superficiellement. Au point de vue morphologique, l'effet d'un drainage prolongé est démontré par le développement de taches de rouille à une plus grande profondeur, traduisant donc une meilleure aération des profils. Dans une série, une couche massive existait à 18 cm de profondeur dans le sol non drainé et elle était remplacée par une couche dense mais plus structurée et plus profonde dans le sol drainé. Dans les horizons sous l'horizon Ap des sols drainés depuis 50 ans, la capacité d'échange cationique était de 12 à 15% supérieure à celle mesurée dans le sol drainé, ce qui peut indiquer de faibles migrations d'argile et de matière organique.

Les mesures de densité apparente et de conductivité hydraulique saturée ne montraient pas de tendance définie. La méthode choisie pour ces mesures était celle des blocs non dérangés et il est probable que trop peu d'échantillons avaient été prélevés, réduisant le taux de confiance pour des valeurs qui de façon générale peuvent varier assez considérablement par suite des caractéristiques inhérentes au sol lui-même.

## FERME EXPÉRIMENTALE LA POCATIÈRE

### Les plantes fourragères

*Régie du semis.* Sur un loam sableux, les semis de luzerne faits à la fin de mai ont eu à la première coupe un rendement de 50% inférieur aux semis du début de mai. À la deuxième coupe en octobre, il n'y avait plus de différence entre les semis de mai. Les semis faits à la mi-juin ont eu un rendement pour les deux coupes de 75% inférieur aux semis effectués au début de mai. À la première coupe, l'année suivant la semis, il y avait encore 36% moins de rendements dans les semis de juin comparativement à ceux de mai. Le 2,4-DB a abaissé la hauteur, le contenu en luzerne du fourrage et la pourcentage de matière sèche de la luzerne dans les semis de juin mais non dans ceux de mai.

L'enrobage de la semence de luzerne semée dans un sol bien cultivé n'aide pas à son implantation. Et cette technique ne semble pas non plus favoriser une meilleure production les années suivantes.

Les semis des plantes fourragères dans un sol non labouré est une technique délicate d'application. Le placement de la semence est un problème majeur et les semoirs utilisés à date n'ont pas encore permis de la résoudre. La grosseur et la forme des semences des plantes fourragères rend difficile leur placement au niveau du sol. La période de temps nécessaire entre le semis et la mise en production est plus longue pour les semis en sols non labourés que pour les semis conventionnels.

*Régie de coupe.* On a soumis un semis de trèfle rouge cultivé sur un sol argileux à différentes fréquences de coupe au cours de 3 années consécutives après celle de son implantation. À la troisième année de récolte, on a observé que pour les traitements de deuxième coupe répétés à tous les 20 jours, le trèfle rouge avait complètement disparu peu importe la date de la première. Quelques parcelles contenaient encore du trèfle rouge aux traitements 15 juin—40 jours et 15 juillet—30 jours, de même qu'aux traitements 1er juin—50 jours et 30 juillet—50 jours. Le contenu en trèfle rouge de ces parcelles était généralement assez faible. Pour les traitements d'une coupe, seulement 70% des parcelles contenait encore du trèfle rouge et un bon nombre d'entre elles avaient une bonne population.

*Chiendent.* Le bas-9052 (BASF) a donné une excellente répression du chiendent à l'établissement et dans les plantations établies de luzerne. Le meilleur résultat a été obtenu en utilisant le taux recommandé divisé en deux applications dont une au stade un à trois feuilles (0,6 kg/ha) et l'autre au stade quatre à six feuilles (0,6 kg/ha).

### Les céréales

*Spargoute.* On a étudié les effets de divers dosages de N et de certains herbicides sur la spargoute (*Spergula arvensis* L.). La biomasse maximale de la spargoute a été atteinte avec N à 80 kg/ha. L'augmentation de la biomasse a été de 80% par rapport au témoin non fertilisé. Une réduction de 50% de la biomasse de la spargoute dû à une traitement au mcpa au stade quatre ou cinq feuilles de l'avoine n'a pas produit d'augmentation de rendement dans l'avoine. L'association linuron mcpa appliqué au stade 15–20 cm de l'orge cv. Laurier a retardé l'épiaison et la maturité de la culture.

*Chiendent.* On a conduit une expérience ayant pour but d'établir la valeur des critères de la densité et de la biomasse dans les études de l'interférence du chiendent (*Agropyron repens* L.) Beauv. sur l'orge. La densité des tiges et la biomasse aérienne du chiendent n'ont pas la même corrélation avec le rendement ou avec le pourcentage en grain de la biomasse dans l'orge. Les analyses de régression suggèrent qu'une relation linéaire décrit de façon adéquate les relations entre rendement et biomasse et entre rendement et densité. La densité donne un pourcentage de réduction de rendement de 64%; pour la biomasse, ce pourcentage n'est que de 40%. Il semble donc que la densité du chiendent permet de déterminer le niveau de perte de rendement dans l'orge de façon plus précise que la biomasse. Une augmentation de la densité moyenne du chiendent de 10 tiges/m<sup>2</sup> provoque une perte moyenne d'environ 6 g/m<sup>2</sup>. La densité du chiendent semble également un meilleur critère que la biomasse pour estimer les variations du pourcentage de grain; la relation est aussi de type linéaire.

### Les pommes de terre

*Sélection des lignées.* Un millier (1098) de lignées provenant de Fredericton (N.-B.) et sélectionnées au stade de quatre buttes (F<sub>2</sub>) ont été plantées sur deux sols (Saint-André et de l'Anse) après prélèvement de deux germes



de chacune de ces lignées afin de la maintenir en éprouvettes. À l'arrachage, 87 et 85 lignées ont été sélectionnées sur le premier et deuxième sol respectivement; de ce nombre, 22 coïncidaient. La sélection a porté alors sur l'apparence des tubercules, le type, le calibre, la maturité, l'absence de défaut et autres caractères. Les résultats d'essais de croustilles et de cuisson ainsi que le poids spécifique et le rendement comparativement au Norland, au Superior et au Kennebec a semblé favoriser 69 de ces lignées. Sur ce nombre, 13 ont été communes aux deux sols et seulement deux ont été bonnes pour les croustilles et la cuisson en 1979.

*Irrigation.* En 1979, un apport de 2,5 cm d'eau lorsque la tension du sol était à 0,2 bar a augmenté les rendements de 30% sur un loam argileux Saint-André et de 50% sur un loam sableux Saint-Pacôme. Le rendement des gros tubercules a doublé sur le loam Saint-André et triplé sur le loam Saint-Pacôme. Avec l'irrigation, le poids spécifique a passé de 1,061 à 1,073 sur le loam Saint-André et de 1,059 à 1,070 sur le loam Saint-Pacôme. Au début d'août, on a mesuré les mêmes différences qu' la fin de la saison dans le rendement des tubercules.

*Les défanants.* Une fertilisation élevée en azote a réduit la dessiccation des feuilles du cv. Kennebec par le diquat, le diquat avec un mouillant et le diquat précédé de l'éthrel. La réduction a été particulièrement importante avec le diquat précédé de l'éthrel.

*Les herbicides.* Le bas-9052 (BASF), le bas-479 (BASF), le métolachlor et le mélange métolachlor-metribuzin ont été des produits très efficaces sur les graminées annuelles. Le bas-9052 a donné en plus une excellente répression du chiendent.

### Les arbres fruitiers

*Pommes et poires.* Des trois porte-greffes utilisés pour la McIntosh et la Quinte, ce sont respectivement Q-8 et Q-5 qui ont permis les meilleurs rendements moyens (48,8 et 21,8 kg/arbre) pour des arbres plantés en 1968. Le rendement moyen des greffes de 1969 sur le M.R. (*Malus robusta*) a été de 65,7 kg et ce sont le Lindel et l'Imperial qui priment avec 105,4 et 94,4 kg/arbre respectivement. Par contre, c'est la Lobo qui a produit le plus depuis les débuts de la production.

La qualité des fruits a été grandement affectée par la rouille et c'est la variété Quinte

qui est la plus sensible. De plus, pour la seconde année, la variété Rangers a été brûlée par le soleil et la sécheresse (water core). Les poiriers plantés en 1944 ont donné de bons rendements (175,2 kg/arbre) et c'est la variété Phileson qui a produit le plus (298,5 kg/arbre).

## FERME EXPÉRIMENTALE NORMANDIN

### Dates de semis de la luzerne

L'établissement et la production des variétés Iroquois, Saranac et Titan ont été vérifiés pendant 6 ans dans des semis effectués aux dates suivantes: 25 juillet, 5 et 15 août. Aucune différence entre les variétés quant à la production de matière sèche n'a été observée pour chacune des dates considérées. Cependant, la production totale d'herbage a régressé, comparativement à un semis fait en mai, de 25, 31 et 42% respectivement selon les dates, et la contribution de la luzerne au rendement s'est établie à 58, 51 et 36% dans le même ordre. À la première année d'exploitation, la production d'herbage a été faible, mais elle a augmenté sensiblement au cours de la deuxième année.

### Vérification de cultivars de gourgane

Quatorze de ces cultivars ont été mis en terre en 1979. La forte pluviosité enregistrée en mai et juin a causé une grave pourriture des racines, entraînant une réduction de 32% dans le nombre de plants viables. En juillet, les températures élevées ont provoqué la coulure des fleurs, diminuant considérablement la pollinisation. Ces deux phénomènes associés ont donné lieu des rendements en grain vert inférieurs de 67% ceux obtenus lors des années favorables. Ces observations démontrent clairement que cette culture est très sensible aux conditions climatiques et que sa rentabilité n'est pas toujours assurée d'une année à l'autre.

### Les plantes horticoles

*Régie du concombre.* Les résultats de six années de production ont démontré l'avantage d'utiliser un paillis constitué d'une pellicule de polyéthylène clair pour un rendement accru du concombre. Le rendement moyen, en unité par parcelle, a été de 42,3% supérieur à une plantation conventionnelle sans paillis. Les dimensions de ce légume n'ont cependant pas

été affectées par la présence de la pellicule qui, par ailleurs, semble contribuer à prolonger la floraison et à produire davantage de petits concombres en fin de récolte saisonnière. La température du sol, à une profondeur de 7 cm, a été en moyenne de 4,5°C plus élevée sous paillis que sur sol nu et ce facteur pourrait en partie expliquer la hausse du rendement.

### Les céréales

*Amélioration du blé.* Deux cultivars sélectionnés localement pour divers caractères

désirables ont été promus dans l'essai coopératif Maritimes-Québec et l'un d'eux a manifesté un potentiel de rendement supérieur à des variétés connues. De plus, 15 autres sélections locales ont été vérifiées à quatre postes d'essai pour leur adaptation spécifique au nord du Québec, et 61 lignées de génération peu avancée ont fait partie de sélections préliminaires; certaines d'entre elles sont prometteuses.

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## INTRODUCTION

Les buts et objectifs de la station de recherches à Saint-Jean portent principalement sur la solution des problèmes touchant la culture des fruits et légumes ainsi que celles du tabac et du maïs grain. L'équipe de chercheurs et le personnel de support concentrent présentement leurs efforts dans les domaines de la production et de la protection. Cependant, certaines énergies sont orientées vers les problèmes de la conservation de la pomme après la cueillette, le séchage du tabac ainsi que la machinerie servant à la production et à la récolte. La création de nouveaux cultivars de pommes ainsi que de nouvelles racines souches de pommiers résistantes à nos conditions climatiques demeure un programme d'envergure nationale. La régie des cultures maraîchères en sols organiques est aussi d'intérêt national, grâce à une étroite collaboration de chercheurs des divers instituts d'Ottawa ainsi que de chercheurs attachés à des stations de recherches de l'est du Canada.

Quelques-unes des réalisations importantes décrites dans ce rapport sont:

- (a) les possibilités de développer une industrie de la prune dans le Bas-St-Laurent;
- (b) la mise en place des techniques de lutte intégrée pour le contrôle des insectes de verger et la réduction des coûts de contrôle;
- (c) la possibilité d'utiliser la méthode STOP dans le contrôle de la tavelure de la pomme;
- (d) la possibilité d'utiliser les tourbières de Terre-Neuve pour la production de légumes;
- (e) l'utilisation de cultivars de carottes résistants aux nématodes cécidogènes;
- (f) la résistance du doryphore de la pomme de terre aux insecticides organophosphorés;
- (g) Delhi 76 demeure le cultivar de tabac jaune le plus rentable au Québec;
- (h) l'urée est la meilleure source d'azote pour le tabac à cigarette.

Ce rapport contient un court résumé des résultats des recherches poursuivies en 1979. On peut obtenir des exemplaires des publications mentionnées à la fin de ce rapport ou des renseignements supplémentaires en adressant sa demande directement aux chercheurs ou à la station comme suit: Station de recherches, Agriculture Canada, Casier postal 457, Saint-Jean (Québec) J3B 6Z8.

Jean-Jacques Jasmin  
Directeur

## ARBRES FRUITIERS

### Gestion des pommeraies

*Cultivars.* Une réduction générale du rendement obtenu en 1979 reflète possiblement le dommage dû au gel qu'ont subi les bourgeons à fruit des pommiers lors d'une gelée printanière. On notait en effet au moment de la floraison un certain nombre de fleurs dont les pistils étaient nécrosés, dégât typique d'une gelée des bourgeons au début du printemps. Les cultivars Hardispur, Mor Mac Spur, Spartan, Jersey mac, Jonamac, Vista Bella et Empire ont produit les meilleurs rendements de fruits vendables à notre ferme à Frelighsburg. Jaune Transparente, Lodi et Melba ont mieux résisté au froid à l'institution La Macaza que n'importe quel des cultivars plus tardifs. Cependant, le porte-greffe semble influencer beaucoup sur la survivance à l'hiver.

Les cultivars de poirier Phileson 31800, Moc, Phileson 31811 et Enie rapportèrent les

plus forts rendements alors que Baïersmith et Patten ont une qualité et un pourcentage très élevé de solide.

Les cultivars de prune plantés à La Pocatière commencent à rapporter des fruits et les cultivars Irsigner et Victoria donnent de bons rendements à Frelighsburg.

*Fertilisation (fumures).* Le porte-greffe 0-3 s'accommode d'un pH plus bas que les autres porte-greffes et donne de forts rendements à un pH de 5,7. Les plus forts rendements ont été obtenus par une fertilisation complète avec faible dose de N, de K ou de Ca. Les plus bas rendements sont associés à une carence ou à une faible fertilisation en P ou Mg. Le porte-greffe 0-3 est celui qui souffre le plus d'une carence de Mg. Le M-26 s'accommode d'un faible niveau de Mg et le M-9 est le plus exigeant en fumure totale. Les relations sol, feuille, porte-greffe, variété, fumure, qualité, volume font l'objet de nos préoccupations.

*Interaction Alar : Simazine.* Contrairement à certaines croyances, l'interaction Alar : Simazine ne semble pas affecter sensiblement les pommiers. La Simazine augmente le nombre de feuille par pousse, la teneur en N et provoque un mauvais aoûtement des arbres. L'action d'Alar n'augmente ni ne diminue cette action physiologique de la Simazine sur les tissus végétaux. Des travaux se poursuivent dans ce sens. L'Alar provoque une baisse et la Simazine une faible augmentation du poids moyen d'un fruit sans qu'il y ait une réelle interaction.

### Protection des pommeraies

*Insectes.* L'acarien prédateur *Amblyseius fallacis* a été introduit dans une parcelle de pommiers semi-nains Imperial McIntosh, le 4 juillet 1979, à raison de 50, 100 et 200 prédateurs par arbre, lorsque la densité de la proie (tétranyque à deux points et tétranyque rouge) était de 8 tétranyques par feuille. Les formes prédatrices ont atteint leur densité maximale, soit 6 prédateurs par feuille, 5 semaines après cette libération, alors que la densité des formes phytophages était bien au-dessous du seuil de tolérance, i.e. 10 tétranyques par feuille pour le reste de la saison.

Dans le but de trouver une méthode permettant de déterminer les formes mortes et vivantes de l'ériophyide du pommier, *Aculus schlechtendali* (Nalepa), plusieurs techniques ont été essayées. De ces différentes méthodes, la détection de l'activité enzymatique demeure la mesure la plus précise. Cette méthode nous a permis d'entrevoir une application des plus intéressantes: un moyen de comptage rapide et efficace des tétranyques.

Cette méthode consiste à détecter la présence de la déshydrogénase malique chez les individus vivants au moyen d'un spectrophotomètre.

Des piégeages ont été effectués dans dix vergers commerciaux et dans deux vergers négligés au moyen de phéromones sexuelles de synthèse dans le but d'établir les relations captures-dégâts et d'utiliser des techniques et méthodes de lutte intégrée. Les résultats obtenus permettent d'établir dans chaque verger les données phénologiques du développement des pommiers, les relevés météorologiques, la somme des degrés-jours, l'époque et le nombre de captures de cinq ravageurs (carpocapse, petit carpocapse, tordeuse du pommier, tordeuse à bandes rouges et tordeuse à bandes obliques) ainsi que le pourcentage de pommes

attaquées par ces insectes en regard des insecticides appliqués. L'adoption d'un tel programme permet de réduire de 20% le nombre de traitements insecticides.

*Maladies.* Le Captane 80 WP a été utilisé selon la méthode STOP après les périodes d'éradication suivantes: 18, 24 et 30 h. On a obtenu respectivement pour chacune des périodes d'éradication le pourcentage de tavelure suivant: 2,0, 2,3 et 3,8. Il est donc possible d'obtenir une répression satisfaisante de la tavelure avec 6 applications de fongicides comparativement à 12 suivant la méthode standard.

Trois fongicides systémiques, le bénomyl, le fenarimol et le méthylthiophanate ont été appliqués contre la tavelure avec de bons résultats.

## PETITS FRUITS

### Gestion du bleuet

L'incorporation de tourbe de mousse au sol, avant la plantation, s'avère supérieure à l'incorporation de bran de scie. De plus, un paillis de bran de scie semble donner de meilleurs résultats que l'irrigation. Le cultivar Northland (hybride nain × géant) sélectionné au Michigan donne des rendements encore plus intéressants que Blueray. Quelques sélections de la collection Vandal (croisement nain × géant 18-116, 18-157, 18-275, 19-129, 20-43) ont commencé à donner des rendements intéressants.

### Gestion du framboisier

Les cultivars Kentville 70-11, Killarney, Festival, Boyne, Kentville 69-4, Matsqui, Kentville 70-15, Haida et Newburg ont donné dans cet ordre décroissant de bons rendements, car ils n'avaient pas été endommagés par l'hiver qui a été clément. L'irrigation des framboisiers a augmenté les rendements de 20 à 40%.

## LÉGUMES

### Gestion des crucifères

*Cultivars.* Les essais de cultivars ont démontré que les choux Hybride Safe Keeper, Storage Green et F<sub>1</sub> Mercury ont donné de hauts rendements avec des qualités horticoles supérieures. Green Hornet, Southern Comet, Bravo, Green Comet et F<sub>1</sub> Dandy ont produit



un meilleur rendement que tout autre cultivar de brocoli inclus dans les essais cette année. Whitetop et Dehra étaient les meilleurs cultivars de choux-fleurs et Jade Cross et Jade Cross E étaient les meilleurs choux de Bruxelles avec le meilleur rendement. Les croisements et rétrocroisements entre le rutabaga, *Brassica napus* × chou × chou sélectionné en 1977 pour sa résistance à la hernie des crucifères ont été croisés avec les choux Houston Ever Green, April Green et Badger Shipper dans le but d'améliorer les qualités horticoles. Des sélections de ces derniers croisements ont maintenu leur résistance aux races 2, 2A et 6. D'autres croisements résistants ont été effectués avec le brocoli.

### Gestion des sols organiques

En comparant les travaux faits à Colinet (T.N.) et dans le sud du Québec, nous voyons qu'il y a des endroits à Terre-Neuve qui ne sont pas suffisamment drainés et que par contre, certains endroits au Québec sont surdrainés. Il faut également prendre en considération que seule l'aération des premiers 20 cm de sol affecte la pousse des plantes. Ceci implique que certains travaux de préparation du sol peuvent avoir plus d'importance sur la récolte que le drainage.

### Production des légumes

Il y a une corrélation entre la densité minimale du sol et l'indice pathologique (I.P.) de la pourriture des racines du pois de conserve. La densité du sol augmente avec la grosseur du tracteur qui opère sur ces fermes et il semble que différentes argiles de la même série, mais localisées à différents endroits, réagissent différemment.

La variété de pois hâtif (1100 à 1300 U.T.) Canner 69-190 a donné les meilleurs rendements suivis de Cameo, Dot et Dawn sur un même pied d'égalité. Andes, une variété tardive, a donné les meilleurs rendements dans les essais et Canner 488 a retenu l'attention avec l'indice moyen le plus bas dans les variétés tardives (1500 U.T. et plus).

Des plantations de semences pré-germées de laitue et d'oignons placées dans une gélatine fluide ont indiqué un certain degré de hâtivité sur les semis ordinaires dans nos conditions climatiques.

Des mesures de réflectance dans le spectre visible et dans l'infra-rouge ainsi que des mesures de fluorescence induite par laser ont été prises dans le but de pouvoir prédire à

distance la date de maturité des laitues pommées. Des lectures de pigmentation (chlorophylle et carotène) ont également été faites dans le but d'établir une corrélation possible entre la pigmentation et la courbe de maturité.

### Protection des cultures

Lorsque le taux de fonofos se maintient entre 30 et 40 ppm, que la température est maintenue à 12°C et que l'humidité est de 180 ± 20%, il agit comme un très bon insecticide contre la mouche de l'oignon. Cependant, le sol réagit fortement avec cet insecticide et différents sols organiques produisent un taux de rémanence qui varie de huit à dix fois immédiatement après l'application. Nous étudions ce phénomène et essayons de détecter les facteurs les plus importants qui affectent la rémanence des pesticides.

Des études sur l'hivernement du nématode cécidogène, *Meloidogyne hapla*, nous ont permis de réaliser que des infestations faibles peuvent être mises en échec par un labour d'automne combiné à un bon programme de rotation.

La résistance de certains cultivars de carotte au nématode *Meloidogyne hapla* a été évaluée dans des micro-parcelles infestées avec différents niveaux de population. Spartan Classic, Spartan Sweet, Trophy et Hybride (1302 × 0541) × 872 se sont révélés significativement plus résistants que le témoin cv. Gold Pak.

Des essais de laboratoire réalisés sur des doryphores de la pomme de terre adultes et provenant d'une région à pomme de terre de la province de Québec ont permis de déceler chez ces insectes un fort taux de résistance au Furadan et à plusieurs insecticides organophosphorés.

## MAÏS

### Gestion de la production

Il a été déterminé que sous nos conditions climatiques du Québec, il est préférable de labourer le maïs à l'automne et de herser les champs au printemps. Les méthodes de non-travail du sol réduisent les rendements et augmentent la compaction.

Le travail de recombinaison des gènes et de création de nouvelles lignées de maïs grain se continue dans le but d'obtenir des lignées hâtives, productives, résistantes au sol froid, à la pyrale, à la kabatiellose et à la fusariose.

## Protection

La production de masses d'œufs de pyrale du maïs pour les laboratoires de recherche et l'industrie canadienne se poursuit activement. Les travaux de coopération avec plusieurs pays dans le but d'augmenter la résistance naturelle du maïs aux attaques de la pyrale donnent des résultats intéressants et nous avons maintenant un vaste réservoir de matériel résistant.

## TABAC

### Production

*Cultivars.* Les essais comparatifs se poursuivent entre des lignées commerciales de tabac à cigare et 22 lignées (F11 à F16) qui proviennent de nos programmes d'hybridation. Des lignées diploïdes (dihaploïdes) ont été obtenues à partir de plants haploïdes produits par culture de tissus. La variété Delhi 76 (tabac à jeune) demeure toujours celle qui produit le plus haut rendement de tabac de qualité, donc le meilleur revenu à l'hectare.

*Façons culturales et fumures.* Un rapprochement des plants sur le rang accroît sensiblement le rendement du tabac à cigare sans en altérer la qualité. Le stade d'écimage affecte aussi le rendement du tabac. C'est avec un écimage au stade 50% de floraison que l'on obtient le meilleur rendement et le revenu le plus élevé.

Les différentes sources d'azote ont une influence sur le rendement et la qualité du

tabac à cigarette. Les meilleurs résultats ont été obtenus avec l'urée, sur les sols Upland alors que pour les sols Soulanges, l'urée réduit la qualité et le nitrate de potasse réduit les rendements.

### Protection

*Maladies.* Dans le but de contrôler la maladie du chauffage à la pente du tabac à cigare, des échantillons hebdomadaires de tabac ont été pris chez deux producteurs à partir de la récolte jusqu'à la fin du séchage. L'étude a démontré que la saprophyte rencontrée dans plus de 90% des isolats a été l'*Alternaria alternata* qui n'est pas un agent initiateur de la maladie. Les autres organismes saprophytiques isolés en de rares occasions ont été des *Fusarium* spp. et des *Sclerotinia* spp. Aux deux stations sous observation, le séchage s'est poursuivi dans des conditions favorables et aucun isolat de *Botrytis cinerea*, le principal agent de la maladie, n'a été repéré.

L'humidité relative durant le séchage a oscillé entre 20 et 80% pendant que la température se maintenait en moyenne à 2 ou 3°C au-dessus de la température extérieure.

*Nématodes.* Il y a une relation étroite entre le développement des populations de nématodes dans les champs de tabac et le type de mauvaises herbes qui poussent. La population de *Pratylenchus penetrans* par gramme de racine séchée atteint 1760 pour le tabac, 1137 pour la persicaire glabre, 488 pour la vesce, 3152 pour le pied-de-coq et 6468 pour la persicaire.

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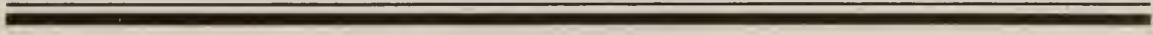
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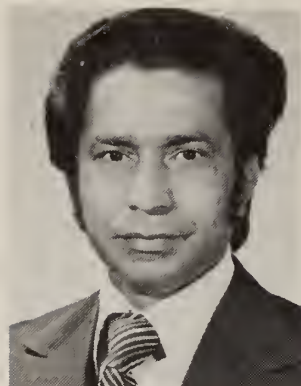
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## PREFACE

The Central Region includes seven research institutes and four research stations, each responsible for specific research programs, and the Research Program Service, responsible for providing editorial, text processing, graphic, and several other services to the entire Research Branch. The Region's establishments employed approximately 390 professionals in 1979, and their total budgets amounted to about \$40 million.

The research institutes have national mandates. At the Animal Research Institute breeding, nutrition, and management research is under way with dairy and beef cattle, swine, poultry, and sheep. Biosystematics research includes taxonomic studies on insects, arachnids, nematodes, vascular plants, and fungi. The Institute also maintains national collections of these biota and provides an identification service. The Chemistry and Biology Research Institute carries out research in specialized areas such as winter-hardiness, nitrogen fixation, and plant diseases. It also provides analytical chemistry and electron microscopy services to other Branch establishments. The Land Resource Research Institute carries out soil surveys in all provinces and performs research in land classification and utilization and in agrometeorology. The Engineering and Statistical Research Institute is involved in research on mechanization, farm structures, and energy. Statistical research in support of branch programs also forms an important activity. This institute is heavily involved in the contracting-out program in areas such as mechanization energy. The activities of the Food Research Institute focus primarily on food processing, food distribution, and food quality and nutrition. The London Research Institute specializes in integrated pest management in both disease and insect pests.

The research stations serve Ontario agriculture through plant breeding research in most major crops and through research in various aspects of agronomy, pest control, and other production technology. The Ottawa Research Station, with its two administratively connected experimental farms at Kapuskasing and Thunder Bay, serves eastern and northern Ontario and specializes in crop breeding and management involving forage and cereal

crops, corn, soybeans, and ornamentals. The Harrow Research Station carries out breeding and management research in tree fruits, field and greenhouse vegetables, and several field crops including corn, soybeans, and field beans. The Delhi Research Station specializes in various aspects of tobacco research including breeding, pest control, and quality research. The Vineland Research Station and its associated Experimental Farm at Smithfield serve the fruit and vegetable growing areas of southern and eastern Ontario. Their research programs are oriented toward improvements of pest control and production technology.

Some key advances at the institutes in 1979 included establishment of the vitamin D requirement for ruminants fed forage in northern latitudes; licensing and commercial assessment of rapeseed technology; demonstration of whey utilization as animal feed; chemical identification of bound pesticide residues; and discovery of peach X-disease transmission by certain leafhoppers. Annotated inventories of pest species of plants, fungi, and insects found in Canada were initiated in 1979. Also, two major books were published: *Budd's Flora of the Canadian Prairie Provinces*; and *The Mosquitoes of Canada*, Part 6 in the series *Insects and Arachnids of Canada*.

Outstanding accomplishments at the research stations included the licensing of the soybean Maple Presto, the first truly short-season cultivar; and the development of a predictive model for carrot rust fly, which reliably forecasts dates of emergence of first- and second-generation adults.

Dr. W. B. Mountain, Director General of Central Region, was seconded to the Management Accountability Directorate as Director General for a period of about 2 yr. Dr. J. G. Saha, Director of the Chemistry and Biology Research Institute, was appointed Acting Director General of the Region.

Further information about our programs may be obtained by writing to the research establishments concerned or by addressing inquiries to Central Region Headquarters, Research Branch, Agriculture Canada, Experimental Farm, Ottawa, Ont. K1A 0C6.

J. G. Saha



## PRÉFACE

La région du Centre comprend sept instituts de recherches et quatre stations de recherches, chacun responsable de programmes particuliers, de même que le Service des programmes de recherche qui s'occupe de la révision et de la publication, du traitement des textes, du graphisme et de divers autres services pour l'ensemble de la Direction. En 1979, ces établissements employaient environ 390 chercheurs et leur budget total se chiffrait aux alentours de 40 millions de dollars.

Les instituts de recherches ont des mandats d'envergure nationale. L'Institut de recherches zootechniques effectue des travaux d'amélioration génétique, de nutrition et de conduite des troupeaux sur les bovins laitiers et de boucherie, les porcs, la volaille et les moutons. La recherche biosystématique englobe des études taxonomiques sur les insectes, les arachnides, les nématodes, les plantes vasculaires et les champignons. L'institut qui en est responsable garde aussi des collections de spécimens et dispense un service d'identification. L'Institut de recherches chimiques et biologiques travaille dans des domaines spécialisés comme la résistance à l'hiver, la fixation de l'azote et les maladies des plantes. Il fournit aussi des services de chimie analytique et de microscopie électronique aux autres établissements de la Direction. L'Institut de recherches sur les terres effectue des prospections géologiques dans toutes les provinces et s'occupe de la classification et de l'utilisation des terres et d'agrométéorologie. L'Institut de recherches techniques et statistiques fait des études sur la mécanisation, la structure des établissements agricoles et l'exploitation de l'énergie. La recherche statistique menée dans le cadre des programmes de la Direction y constitue également une activité importante. Cet établissement anime en outre un important programme de recherches contractuelles dans des domaines comme l'énergie de la mécanisation. Quant aux activités de l'Institut de recherches sur les aliments, elles portent surtout sur la transformation et la distribution de même que sur les aspects qualité et valeur nutritive. Enfin, l'Institut de recherches à London se spécialise en lutte antiparasitaire intégrée contre les maladies et les insectes nuisibles.

Pour leur part, les stations de recherches sont au service de l'agriculture ontarienne par leurs travaux d'amélioration génétique sur la plupart des cultures importantes et par leurs recherches sur différents aspects de l'agronomie, de la lutte antiparasitaire et d'autres techniques de production. La station de recherches à Ottawa avec ses deux fermes expérimentales satellites à Kapuskasing et à Thunder

Bay, dessert l'est et le nord de l'Ontario et se spécialise dans l'amélioration et la conduite des cultures céréalières et fourragères, du maïs, du soja et des plantes ornementales. La station à Harrow se concentre sur l'amélioration et la conduite des arbres fruitiers, des légumes de serre et de plein champ ainsi que de diverses grandes cultures comme le maïs, le soja et le haricot. La station à Delhi se spécialise dans les différents aspects de la culture du tabac comme l'amélioration génétique, la lutte antiparasitaire et la qualité du produit. La station à Vineland et sa ferme expérimentale associée située à Smithfield dessert les régions fruitières et maraîchères du sud et de l'est de l'Ontario. Leurs programmes sont axés sur l'amélioration des techniques de lutte antiparasitaire et de production.

Parmi les progrès marquants réalisés en 1979 par les instituts, citons l'établissement des besoins en vitamine D des ruminants nourris sous les latitudes Nord, l'homologation et l'évaluation commerciale de la technologie du colza, la démonstration de l'usage du lactosérum comme aliment des animaux, l'identification chimique des résidus liés des pesticides et la découverte du mode de transmission de la maladie X du pêcher par certaines cicadelles. On a commencé des inventaires annotés des espèces nuisibles de champignons et d'insectes trouvées au Canada. Deux livres importants ont aussi été publiés: *Flora of the Canadian Prairie Provinces* de Budd et *The Mosquitoes of Canada*, tome 6 dans la série *Insectes et arachnides du Canada*.

Les grandes réalisations des stations de recherches comprennent l'homologation du soja Maple Presto, le premier cultivar véritablement précoce pour notre climat et l'élaboration d'un modèle prévisionnel sur la mouche de la carotte établissant avec exactitude les dates d'apparition des adultes de première et de deuxième générations.

M. W.B. Mountain, directeur général de la région du Centre a été détaché à la Direction de l'imputabilité de la gestion comme directeur général pour une période d'environ deux ans. M. J.G. Saha, directeur de l'Institut de recherches chimiques et biologiques a été nommé, pour sa part, directeur général intérimaire de la Région.

On peut obtenir de plus amples renseignements sur nos programmes en écrivant aux établissements de recherches concernés ou à l'adresse suivante: Administration de la région du Centre, Direction de la recherche, Agriculture Canada, Ferme expérimentale, Ottawa (Ont.), K1A 0C6.

J.G. Saha



# Research Station

## Delhi, Ontario

### PROFESSIONAL STAFF

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#### Tobacco

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J. M. ELLIOT, B.S.A., M.S.A.	Soil science
S. K. GAYED, B.Sc., M.Sc., Ph.D.	Plant pathology
R. S. PANDEYA, B.Sc., M.Sc., Ph.D.	Genetics and plant breeding
N. ROSA, B.Sc., M.Sc., Ph.D.	Plant physiology
E. K. WALKER, B.S.A., M.S.	Plant science
F. H. WHITE, B.Sc., M.Sc.	Genetics and plant breeding
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### EXTENSION SERVICES<sup>1</sup>

M. C. WATSON, B.S.A.	Tobacco
N. W. SHEIDOW, B.Sc.	Tobacco

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<sup>1</sup>Provided by Ontario Ministry of Agriculture and Food.

## INTRODUCTION

The Delhi Research Station is the primary center for research on flue-cured tobacco in Canada. Multidisciplinary research projects on the development of new varieties and on crop production and crop protection practices are conducted. Emphasis is placed on improving the physical and chemical quality of Canadian flue-cured tobacco from the standpoints of usability by manufacturers, both domestic and foreign, and consumer acceptability and health. An engineering program funded by the Canadian Tobacco Manufacturers Council and the Ontario Flue-Cured Tobacco Growers' Marketing Board also conducts research at the Station on the reduction of energy use in curing and on the mechanization of harvesting and handling of tobacco.

A blue mold (*Peronospora tabacina* Adam.) epidemic occurred in the main tobacco belt in Ontario in 1979 and resulted in a loss of about 31 800 000 kg of tobacco or about 30% of the entire crop.

More extensive summaries of research activities are published in the annual *Tobacco Research Report* which is prepared for extension workers and growers. Copies of the *Tobacco Research Report* and scientific publications are available from Delhi Research Station, Research Branch, Agriculture Canada, P.O. Box 186, Delhi, Ont. N4B 2W9.

C. F. Marks  
Director

### SOIL SCIENCE

#### Nutrition survey

On a 32-farm survey, soil pH was positively related to contents of Ca and Mg in the soil and leaf content of Ca. Acid soils had higher contents of Mn and Zn and produced tobacco with higher levels of these two elements. Soil pH was not correlated with Cd in the soil, but Cd in the plant was positively correlated with plant levels of Mn and Zn. Levels of K or Cu in the soil or plant were not associated with pH.

#### Fertilization

In a Fox loamy sand in which 13 consecutive crops of tobacco had been grown with K omitted from the fertilizer, the level of K declined to about 40% of the initial soil test value and the yield was 350 kg/ha lower than from the complete fertilizer treatment. One-half rate of K superimposed on the no-K plots for the 12th and 13th crops resulted in a loss in yield of 165 kg/ha for the 1st yr the half-rate was applied and no loss in the 2nd yr. The omission of K lowered grade quality but the omission of Mg or P had little effect on yield or quality.

### PLANT SCIENCE

#### Seedling culture

Adequate size of Todd cell seedlings for mechanical transplanting was achieved by periodic fertilization of peat-lite types of medium in the cells with sufficient 20-20-20 to obtain a total nitrogen equivalent of 0.012 g per plant. Todd cell seedlings survived better in the field, were more uniform in growth, flowered earlier, and tended to give higher quality and yield than seedbed seedlings. The Todd cell system eliminates plant pulling and is amenable to complete mechanization of the transplanting operation.

Comparisons of muck and a 50/50 mixture of peat and muck and three sequential pullings from seedbeds showed that yield, cash returns, and total alkaloid levels in cured leaves were higher for pulling-one transplants than for other pullings from both seedbed media; transplant survival was lower for pulling-one transplants; grade price, filling value, lamina weight, and reducing sugars in cured leaves were not affected by number of pulling or type of medium. Forking of seedbeds was found to improve survival of seedlings in the field and promote earlier maturity and yield.

## Sucker control chemicals

The use of *n*-decanol in formulations with a surfactant to control axillary bud growth in tobacco tends to reduce total alkaloid content in the lamina. Metabolic processes associated with the accumulation of total alkaloids, particularly nicotine, are affected differently by *n*-decanol versus mechanical removal of suckers. Sucker control chemicals should be applied at the mid-bud stage to provide optimum control of suckers and maximal accumulation of total alkaloids in the lamina.

## Curing

An extensive study with 50 cooperating growers indicated that the effectiveness of ethylene gas for reducing curing time and improving tobacco quality depended upon type of curing system, curing procedure, cultivar, maturity, and length of exposure to the gas. The gas usually promoted faster yellowing and darkened the base color, but some damage, usually insufficient to cause quality deterioration, occurred in certain instances.

## CHEMISTRY

### Effect of cigarette weight and pressure-drop on tar and nicotine in smoke

Flue-cured tobacco leaves from different stalk positions were made into cigarettes and selected within narrow ranges of weight and pressure drop to compare the effects of variable pressure drop at constant weight or of variable weight at constant pressure drop on smoke parameters. Tar and nicotine levels increased and decreased, respectively, with tar and nicotine levels in the smoke; nicotine was affected to a greater extent than tar. Tar and nicotine in the smoke increased with ascending stalk position, but nicotine increased proportionately more than tar.

### Effect of growth, stalk position, topping, and curing on divatrienediol levels of tobacco

Amounts of divatrienediols, important precursors of flavor and aroma constituents in flue-cured tobacco, increased after topping in the middle and upper stalk positions. A general decrease in these diterpenes was observed in all stalk positions prior to topping and continued to decline in the lower plant

positions after topping. Levels of divatrienediols in leaves increased with ascending stalk position. During the curing process the levels of divatrienediols in the leaf declined to about one-half that in the corresponding green leaf tissue. The decline continued in storage after curing.

### Tobacco terpenes in relation to tobacco quality

About 2000 tobacco grade samples were analyzed to examine the relationship of terpenes to grade quality using a diterpene, neophytadiene, as a marker. The association between neophytadiene and grade index was not large but was greater than that obtained for total alkaloids, reducing sugars, and chlorine. The tobacco K grades were much lower in neophytadiene than the corresponding lemon or orange grades.

### Changes in leaf chemistry during curing

Carbohydrate constituents of the leaf, particularly starch, degrade rapidly to simpler sugars during curing. Starch concentrations of up to 50% of dry weight of green leaf at the upper stalk positions declined to a concentration of 1–2% at the end of curing. Sugars from starch degradation increased to 25–30% at mid-curing stage and then decreased to about 16–18% for leaves of middle and upper stalk positions by the end of curing.

## GENETICS AND PLANT BREEDING

### Haploidy studies

A total of 275 doubled haploid lines have been developed in the haploidy program. Most doubled haploid lines tended to be less vigorous following diploidization, but in the  $S_2$  generation complete vigor was restored; therefore, most evaluations are now conducted in the  $S_2$  generation.

### Path coefficient analysis

Multiple linear regression and path coefficient analyses were applied to a number of agronomic, chemical, and physical characteristics to establish a cause-and-effect relationship with wet tar and nicotine in smoke. Over a wide range of flue-cured genotypes, wet tar was found to be dependent primarily on leaf total alkaloids and lamina weight. The negative effects of two agronomic variables, days to flower and topping height, on smoke

wet tar were completely mediated through leaf total alkaloids and lamina weight. Smoke nicotine was essentially determined by three variables ( $R^2 = 88\%$ ): total particulate matter (TPM), leaf total alkaloid, and lamina weight.

### Genetic resistance to blue mold

Observations on about 350 lines demonstrated that none of the Canadian or U.S. lines have resistance to blue mold, or tolerance, or both. The lines CSIRO-40T and CSIRO-3T (resistant to only APT I) were severely infected, whereas Queensland A (resistant to APT I and APT II) exhibited considerable tolerance to blue mold. The line Queensland A and a number of other lines from various areas of the world will be used in a breeding and selection program.

## PLANT PATHOLOGY

### Tobacco stunting

Undefined stunting appears to be due to an interaction of nematodes, fungi, and soil conditions. The problem can be alleviated considerably with the use of fumigant nematocides containing chloropicrin. In a field with a moderate nematode population and slightly infested with black root rot, a line immune to black root rot responded to straight fumigant nematocides and those containing chloropicrin, whereas a relatively tolerant variety and a susceptible variety responded only to the fumigant nematocides containing chloropicrin.

### Stem rot: A new disease

*Botrytis cinerea* Pers. ex Fr. was identified as the causal organism of several severe stem rot infections in late June and early July. Apparently this is the first record of the disease in flue-cured tobacco. Cool, humid weather increased the severity of the disease.

### Blue mold

Application of metalaxyl on experimental plots protected tobacco plants against blue mold caused by *Peronospora tabacina* Adam. In heavily infected fields the application of metalaxyl, chlorothalonil, zineb, maneb, or streptomycin sulfate did not reduce disease severity. Metalaxyl application in the seedbed

before, at, or after seeding at rates between 0.13 and 1.2 kg/ha protected the seedlings against natural infection with blue mold.

Conidia of *P. tabacina* were collected in spore traps till late November, and viable conidia were collected in December. Laboratory tests proved that 14 consecutive freezings and thawings reduced the viability of conidia but did not kill all the conidia tested. Oospores were detected in decomposed leaf tissue and in large numbers particularly in the xylem vessels of the leaf.

### Weather fleck

In 1977 and 1978 ethylene diurea (EDU) significantly reduced weather fleck. In 1979, EDU treatments failed to reduce weather fleck, possibly due to the use of metalaxyl during August to protect the experimental plots against blue mold.

## ENTOMOLOGY

### Cutworms

Cypermethrin, fenvalerate, permethrin, and trichlorfon were applied to tobacco seedlings in the greenhouse to determine their effectiveness and biological insecticidal persistence against the darksided cutworm in Ontario. All insecticides tested reduced cutworm-damaged plants and caused high mortality of the cutworm larvae as compared with the untreated check. Cypermethrin, fenvalerate, and permethrin were more effective and more persistent than trichlorfon and caused no visible phytotoxicity to tobacco seedlings.

### Aphids

Severe aphid infestation (average of 1200 aphids per leaf) reduced total alkaloids and reducing sugars and increased total nitrogen and starch in tobacco leaves. After curing, heavily infested leaves were brown or black in color and of poor grade and quality.

### Effects of tank mix combinations of insecticides and sucker control chemicals

A 5 yr test confirmed that all the aphid and hornworm control chemicals and sucker control chemicals registered for use on tobacco are compatible. Tank mix combinations of these chemicals also had no negative effect on yield or quality of flue-cured tobacco.

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# Research Station

## Harrow, Ontario

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B. N. DHANVANTARI, B.Sc., M.Sc., Ph.D.	Bacterial diseases of vegetables
L. F. GATES, B.A., Ph.D.	Cereal and corn diseases
S. LESAGE, B.Sc., Ph.D.	Pesticide chemistry
J. C. TU, B.Sc., M.Sc., Ph.D.	White bean diseases

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S. E. WEAVER, B.A., Ph.D.	Weed ecology

## Soil Substation, Woodslee, Ont.

J. W. AYLESWORTH, B.S.A., M.S., Ph.D.	Officer in Charge
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## EXTENSION SERVICES<sup>3</sup>

J. C. FISHER, B.S.A.	Greenhouse and vegetable crops
F. KAPPEL, B.Sc.	Fruit and vegetable crops

<sup>1</sup>Seconded from Libraries Division, Finance and Administration Branch.

<sup>2</sup>Seconded from Policy, Planning, and Economics Branch.

<sup>3</sup>Provided by Ontario Ministry of Agriculture and Food.

## INTRODUCTION

The Research Station at Harrow is located in a region with favorable climate and a long growing season. Fruit, vegetables, and field crops are included in the nine Station research programs. Rainfall received, or its distribution, during the growing season is inadequate to meet the needs of all crops in all seasons. During 1979 our season was generally characterized by cool and wet weather. Many crops responded favorably with record or near-record yields; however, some crops were adversely affected. Our research is confined primarily to production problems and includes developing new varieties with superior characters; improving insect, disease, and weed control practices; and improving soil and crop management practices.

This report provides a brief summary of results obtained in 1979. Further information can be obtained by writing to: Research Station, Research Branch, Agriculture Canada, Harrow, Ont. N0R 1G0.

J. M. Fulton  
Director

### FIELD CROPS

#### Burley tobacco

*Production techniques.* Plants from seedlings grown in small pots or in Todd cells had more leaf area at 5 wk after transplanting to the field, and reached flowering and maturity sooner, than plants obtained by the standard method of growing transplants in muck beds. Yield and grade indices were equal.

Time studies indicated that a rack system of handling stalk-cut plants reduced the four or five laborers normally required in the field to two persons. However, four or more racks would have to be assembled on a wagon carrier in order to reduce the time in transporting the plants to the curing barn. Loading the racks into the barn with a tractor-mounted, front-end fork lift was done faster and with less help than the conventional hanging of sticks of plants by hand. The use of rack carriages and an electric chain hoist was more efficient than the fork lift in barn loading the racks. There were no differences in leaf quality between rack-hung and conventional-hung tobacco at three different stick spacings.

#### Corn

*Breeding.* A dent inbred line, CH705-8, was released. It was derived from Funk's G4220. The line requires 2900 heat units to mature and possesses good combining ability for yield, moderate first-brood corn borer resistance, and excellent stalk strength. In addition, a report on Harrow hybrid combinations yield tested in 1970-1975 was released

to the corn industry. Several of these hybrids had superior performance to commercial check hybrids.

*Diseases.* In early-planted varieties, good correlations were obtained between ear growth rate in the early stages and eventual stalk rot in October. Stalk rot in late-planted varieties was more dependent on cultural conditions.

*Herbicide tolerance.* Inbred lines showed significant genetic differences in seedling injury from recommended rates of the herbicide alachlor. Hybrids made up from these inbreds showed less variation in injury as a group. The tolerance of a hybrid could not be efficiently predicted from the tolerance of its inbred parents.

*Insects.* A single-cross corn hybrid which has resistance to the first generation of a multivoltine strain of the European corn borer was compared with a hybrid which is susceptible to both generations, and differences which might occur in the biology of the borer and in yield were observed. In southwestern Ontario the second generation is the more important of the two. There are no commercial hybrids resistant to the second generation.

In the initial year of study the mortality of first-generation eggs was low on both hybrids, but larval survival and plant damage was considerably higher on the susceptible hybrid. Egg mortality in the second generation was also low for both hybrids, but larval mortality was high in each instance, due mainly to a long period of drought. There was no evidence

that the resistant hybrid was more subject to infestation by the second generation.

A small number of second-generation egg masses were parasitized by *Trichogramma minutum* Riley. This is the first report of the insect in this area in recent years.

Mean density of larvae of the northern corn rootworm, *Diabrotica longicornis* (Say), in plots not treated with insecticide in southwestern Ontario from 1975 to 1978 was 6.3 per plant and mean loss of grain corn yield was 0.7 t/ha. Soil treatments of 10% carbofuran and phorate applied at a rate of 1.0 kg/ha reduced rootworm populations by 2.9 larvae per plant and increased yield by 14.2%. The insecticides were similar in their effects on the mortality of larvae. Dry soil conditions reduced larval density and the efficacy of soil insecticides.

Aerial photographs taken from 1969 to 1975 indicated that there was about half as much cropland in corn near Hensall as near Kent Bridge. There was more than twice as much continuous corn near Kent Bridge than near Hensall, and estimated yield losses were 3.1–5.5% and 1.1–2.8%, respectively.

*Liming corn rotations.* Lime applications applied to Brookston clay soil in 1951 produced improved soil tilth occurring 20 yr later, as evidenced by increased pore space. On most rotations and on continuous corn, soil pore space was about 25% greater where lime had been applied.

*Relation of factors to yield.* Regression studies on effect of soil and plant measurements on yield at Woodslee showed that levels of N and K, soil compaction, and soil moisture were the most important factors determining yield differences under several management systems. Other significant factors were rotation, heat units, rainfall, and moisture-stress days. The maximum response to favorable climate was obtained with a rotation which included alfalfa, fertilizer, and good soil tilth.

*Soil fertility.* Studies continued, in cooperation with the University of Windsor, on loss of nitrogen into the atmosphere from fertilized corn plots. Evolution of nitrous oxide was shown to occur within a few days of fertilizer application and to continue for several months. This loss, however, only amounted to 0.25% of the nitrogen applied. Simultaneous loss of nitrogen in other gaseous forms needs to be measured.

*Weed control.* As a result of herbicide evaluation research, cyanazine plus dicamba will be recommended either preemergence or postemergence for general weed control in corn. Bromoxynil or dicamba may now be used for broad-leaved weed control, particularly for the triazine-resistant weeds.

*Weed physiology.* Differential growth and response to atrazine were examined in greenhouse experiments with atrazine-susceptible and atrazine-resistant lamb's-quarters populations from across Ontario. Germination differences did not appear to account for the predominance of susceptible populations in areas that had not been treated with triazine herbicides. Although population differences in early growth were observed, variations in rate of growth following the seedling stage resulted in young plants of more or less equivalent size. Population differences in time to maturation, biomass production, and reproductive effort were correlated with geographic location. Susceptible populations showed marked decreases in plant weight, height, and leaf number with atrazine at 0.5 kg/ha, whereas resistant populations tolerated 5 kg/ha. Atrazine had less effect on certain susceptible populations compared with others, and this may be important in altering the field composition of lamb's-quarters populations when atrazine is used, although change would be expected to be slow.

## Soybeans

*Breeding.* Tests of advanced lines and varieties showed that heritabilities for maturity, plant height, and yield tended to be as high in microplots (five or six plants per hill) as in row plots (four rows 5 m long), thereby indicating that experimental variability was similar in hill and row plots. However, in each of 2 yr, yield performance of entries in hill plots was not correlated with their performance in row plots ( $r = 0.07$  and  $r = 0.01$ ). Thus, selecting for yield in hill plots might not select those lines best suited for row production.

The application of 2,4-DB herbicide during pod-filling appears to stress the soybean plant and makes susceptible/tolerant varieties more likely to be killed by *Phytophthora megasperma* Drechsl. var. *sojae* Hildebrand. The herbicide does not affect disease-resistant varieties. Therefore, this herbicide can be used to increase the disease severity and aid in selecting tolerant cultivars.

**Canada thistle control.** Fields of soybean stubble heavily infested with Canada thistle were treated with glyphosate at 2.25 kg/ha in the spring of 1978 (26 May and 3 June). Soybeans were planted 7–10 days later, following tillage operations, and excellent thistle control was observed in the 1978 soybean crop at both locations. In 1979, Canada thistle control was 98% at both locations, one planted to soybeans and observed in June, and one planted to winter wheat and observed in stubble in September. In addition, a large field treated in the spring of 1977 was virtually free from thistles in 1979.

**Economic analysis of tile drainage.** Soybean producers on Brookston clay soil with widely spaced drains should reduce the spacing of drains to a minimum of between 9 and 12 m in preference to very close spacings. In general, financial returns from simulated continuous soybeans at a given reduction in drain spacing were higher than for continuous grain corn because recent soybean/corn price ratios were favorable to soybeans.

**Herbicide incorporation.** Incorporation of trifluralin plus metribuzin by disc or s-tine implement had no effect on efficacy of the herbicides. S-tine incorporated the herbicides to a shallower depth than the disc which permitted volatile losses of trifluralin up to 52% of that applied compared to a maximum of 15% on disced soil. Chisel or mold-board plowing in the fall had no effect on herbicide degradation or efficacy. Chisel plowing opened the soil to a greater depth than mold-board plowing which resulted in 3% higher water content at 15 cm.

**Pathology.** Results of a survey of 36 soybean fields indicate that races of *Phytophthora megasperma* Drechsl. var. *sojae* Hildebrand have not changed during the past 5 yr. Average incidence of diseased plants in growers' fields was less than 1% and was correlated with increased fertilizer applications and decreased soil drainage.

**Velvetleaf control.** Bentazon provides excellent velvetleaf control when applied post-emergence to the weed, but greenhouse studies confirmed field observations that pre-emergence control also exists. Velvetleaf was controlled by bentazon at 5  $\mu\text{g/g}$  soil when placed in or below the seed zone but not above the seed. Thus bentazon application can be optimized to control more difficult weed

species such as pigweed and lamb's-quarters without losing efficacy for velvetleaf control, provided later precipitation leaches the herbicide to the seed zone.

**Weed control.** Three-way combinations of herbicides provided promising overall weed control. Pre-emergence weed control depends on soil moisture and was poor due to lack of rain. Weed control in broadcast and drilled soybeans was equal, but the latter had a better and more competitive stand.

### White beans

**Anthracnose.** Two approaches were taken to control the disease delta race of *Colletotrichum lindemuthianum*, namely (1) seed treatment with a benomyl formulation and (2) a backcross breeding program for disease resistance. Subsequently, it was found that the fungus developed tolerance to benomyl readily by forming sclerotium-like structures and by developing biotypes capable of radiating mycelial growth in benomyl at 500  $\mu\text{g/mL}$ . Thirteen such biotypes were isolated and characterized in 1979. Thus, a backcross breeding program coupled with screening for disease resistance offers a more permanent solution (see "Breeding").

**Bacterial blight.** A new experimental compound, KT-19827, was found to be of potential value in seed disinfection. Seventy to 100% disinfection from the blight organism, *Xanthomonas campestris* pv. *phaseoli* (Smith 1897) Dye 1978, was effected by the compound at rates of 0.32–0.65 g/kg of seed without adverse effects on seed germination. Minimum inhibitory concentration of the compound to strains of blight bacteria was 62.5–125  $\mu\text{g/mL}$  in vitro.

Significant reduction in number of pods, filled pods, seeds, and seed weight resulted from artificial field inoculations of cv. Seafarer with blight bacteria 4 wk after planting. Three weekly sprays of Kocide-101 (Kennecott Copper Corp., 86% cupric hydroxide), at a rate of 1.12 kg/ha beginning from a month after artificial field inoculations, resulted in less pod infection and an increase of filled pods, seeds, and seed weight.

**Breeding.** In the greenhouse, 36 tolerant lines were selected from screening 877 lines. In the field, six preliminary selections and two advanced selections were tolerant. In the observation rows, 77 lines showed varying degrees of tolerance.

The "Are" gene for resistance to bean anthracnose, caused by *Colletotrichum lindemuthianum*, has been transferred from P.I. 326418 to Seafarer, Kentwood, and Fleetwood using six backcrosses. This gene confers resistance to the alpha, beta, gamma, and delta races of the fungus. These varieties did have resistance to the alpha, beta, and gamma races but not to the delta race which appeared in Ontario in 1976. The original varieties sometimes showed very small lesions when inoculated with the alpha, beta, and gamma races, whereas the new varieties are immune to all four races. Seed has been obtained from homozygous resistant, backcross-derived lines.

**Viruses.** A high incidence of mosaic diseases of white beans was observed in southern Ontario. Two severely affected fields had 35 and 80% of the disease incidence; yield loss in them approximated up to 26 and 40%, respectively. The causal viruses were isolated and identified as a severe strain of tobacco ring-spot virus (TRSV-S) and a strain of bean yellow mosaic virus (BYMV). All currently recommended cultivars (Fleetwood, Kentwood, Sanilac, and Seafarer) are susceptible to both viruses. The white-seeded bean cvs. Amanda, Great Northern (GN) U1-34, GN U1-123, and Imuna were found to be resistant to both.

**White mold.** Of 82 fields surveyed, 42 had white mold. Severity in 1979 appeared to be related to cool-wet summer months. Foliar sprays of benomyl, chlorthalonil, and thiofanate were effective in controlling this disease, although timing and delivery of spray require investigation to maximize chemical control.

### Winter wheat

**Breeding.** Promising winter wheat strains have been developed which combine high yield, resistance to wheat spindle streak mosaic, lodging resistance, and acceptable test weight. The five best lines had 14% yield advantage over Fredrick, the commonly grown cultivar. Other lines have been developed which are resistant to some forms of winter stress, have improved nutritional value, or have genes associated with high productivity.

**Diseases.** Selections are being made from crosses of commercial cultivars with the cultivar Halytchanka, which is resistant to

wheat spindle streak mosaic. Two lines were entered in the Ontario screening test.

## HORTICULTURAL CROPS

### Field vegetables

#### Asparagus

**Time of seedling setting.** A new technique for establishing asparagus fields involves seeding asparagus in the field and then at a later date lowering the seedling the required 15–20 cm into the soil. A 3 yr study suggested that a late-summer lowering of asparagus seedlings during the year in which they were seeded has some advantage over a spring treatment 1 yr after seeding. If, however, a grower wishes to wait for a spring setting then a very early treatment has definite advantages over a setting in the late spring.

#### Beet

**Bed seeding equipment.** A disk-opener, multi-row seeder (18 rows per metre) was developed in conjunction with the Engineering and Statistical Research Institute for high-density seeding of root crops. Seed germination was uniform within the rows and between the rows. The furrowing effects, often very pronounced with other bank seeders, was at acceptable minimal levels.

#### Crucifer crops

**Chinese cabbage protection.** The recommendations for root maggot control in cabbage and cauliflower proved inadequate for Chinese cabbage, since the developing heads provided sites for oviposition by second-generation flies. Sprays applied every 10 days gave only 60% clean heads.

**Insect control by pathogens.** Viruses and/or *Bacillus thuringiensis* were applied when numbers of cabbage looper and cabbageworm exceeded preestablished thresholds. This study, initiating development of an integrated pest management program for crucifer crops, demonstrated the benefit of treatment based on monitoring; seven applications of microbial insecticide were required at Harrow where populations of these leaf-eating pests were high, whereas only three applications were required at Cambridge where populations of the pests, especially the cabbage looper, were comparatively low.

Selection for fast- and slow-killing strains of the nuclear polyhedrosis virus of the

cabbage looper over 20 serial passages in host larvae by ingestion yielded strains of virus that killed in 5.5 and 9.5 days after ingestion of the virus compared to 6.0 days by the unselected strain. Inability to select a strain that killed faster than the wild virus would be expected, because selection in nature would be for the fastest-killing strain.

Studies at the University of Guelph supported by a Harrow-sponsored EMR grant showed that the parasitoid *Apanteles glomeratus* can transmit granulosis virus from virus-diseased to healthy larvae of the imported cabbageworm.

### Cucumber

*Breeding and testing.* Fourteen Harrow F<sub>1</sub> hybrid picklers were evaluated in on-Station and off-Station trials. Harrow 77.01 and 78.05 gave the best overall performance in terms of productivity and fresh and salt-stock quality. It is anticipated that 77.01 and 78.05 will be named and introduced in 1980. Both hybrids are highly tolerant to angular leaf spot, *Pseudomonas lachrymans* (Sm. & Bryan) Carsner, and to cucumber mosaic virus and are resistant to scab, *Cladosporium cucumerinum* Ell. & Arth.

### Peppers

*Forecasting corn borer damage.* Forecasts of corn borer damage from the number of moths caught in one light trap were shown to be significantly better than forecasts from five pheromone traps. The product obtained from multiplying the number of moths by the average age of female moths, estimated by dissection, was more closely correlated with subsequent damage than the number of moths used alone.

*Insect control.* European corn borer and green peach aphids were effectively controlled by regular sprays of five insecticides. The best were acephate, fenvalerate, and profenofos. An experimental insect growth regulator, BAY SIR 8514 (Mobay), gave borer control but did not affect aphids.

### Potatoes

*Aphid control and yields.* About equal numbers of green peach aphids and potato aphids were controlled by sprays of pirimicarb or methamidophos, or a granular application of aldicarb. There was an inverse relation between aphid numbers per 100 leaves and the resulting yield.

### Sweet corn

*Forecasting corn borer populations.* Studies showed that the population of borers in sweet corn plants could be forecast from catches of moths of the previous generation 3–5 wk earlier, using the same methods as for peppers.

*Insect control.* The second generation of European corn borer was well controlled by a number of insecticides applied on a flexible schedule depending on the number of corn borer moths flying. Early sweet corn varieties showed an interesting range of susceptibility to first-generation borers.

### Tomatoes

*Bacterial speck.* Following a serious outbreak of bacterial speck (causal agent *Pseudomonas tomato*) in fresh-market and processing tomatoes in 1978, tomato transplants raised in local greenhouses were suspected to be an inoculum source. A survey by questionnaire of greenhouses in Essex and Kent counties in 1979 revealed that bacterial speck occurred on some of the transplants in a few greenhouses in mid-May. The disease seemed to be associated with exposure of the plants to the weather elements, as greenhouses are opened in early May. Although disease-free transplants (both local and imported plants) were field planted, another survey indicated that local transplants were more susceptible to bacterial speck in the field than the imported plants.

*Direct seeding of tomatoes on clay.* A direct-seeding experiment, repeated in 1979, again showed that processing tomatoes (cv. Quinte) could be established satisfactorily on Brookston clay soil by using combined techniques such as pregerminated seed, plug-mix planting, and fall-prepared beds. For commercial application, delayed maturity and weed control problems should be overcome by using suitable early cultivars and recently developed chemical weed-control methods.

*Field-seeding methods.* Evaluation of four seeding methods showed that when the seed is dispensed in a water-retaining gel which is placed at the bottom of the furrow and then covered with an anticrustant plug mix (gel – plug mix seeding technique), superior rates of emergence and superior final field germination percentages were obtained than when planet junior (raw seed), plug mix, or gel seeder seeding methods were used.

*Georgia-grown transplants.* Since Georgian tomato transplants are now being machine harvested, all seedlings, even the very thin-stemmed ones that would have normally been discarded with hand harvest, are included in the shipment to Ontario. It was determined that the very thick-stemmed transplants gave higher early yields than either the normal or thin-stemmed transplants. It was also shown that ethephon spraying of thick-stemmed transplants a few days prior to pulling in Georgia further increased early yields over their control counterparts.

*Herbicide tolerance.* In fresh-market tomatoes, it was shown that metribuzin applied between 10 and 30 days after transplanting had no detrimental effect on the crop yield.

*Irrigation schedule.* Irrigation schedules to maintain 50% available soil moisture (ASM) on Fox sandy loam for processing tomatoes were obtained from soil-moisture and climate-based approaches. Good agreement was found between irrigation schedules estimated by these two approaches. Daily maximum and minimum air temperatures, sunshine duration, and rainfall during the growing season are required for climate-based irrigation schedules.

*Pesticide residues.* Copper and ethylenebis-(dithiocarbamate) (EBDC) fungicides gave effective control of bacterial speck (*Pseudomonas tomato*) on field tomatoes. The interference of cupric ions on the analysis of EBDC residues in tomato juice was quantitated. An in vitro study on the thermal degradation of EBDC fungicides in aqueous solution showed that the addition of cupric ions prevents the formation of ethylenethiourea which is a known carcinogen and teratogen.

*Plant population density and irrigation.* Yields of marketable tomatoes reached a maximum in the plants irrigated at 50% ASM when the fruits were rapidly enlarging. The plants which received more applications of irrigation water (50% ASM throughout the growing season) did not produce any further increase in yield. High density (43 054 plants per hectare) of H2653 variety outyielded low density (10 765 plants per hectare) by 108% and outyielded medium density (21 527 plants per hectare) by 40%; medium density outyielded low density by 40%. High density (21 527 plants per hectare) of C28 outyielded low density (10 765 plants per hectare) by

22%. Measurements of plant water status (i.e. leaf water potential and stomatal conductance) indicated that plants in a high population had equal availability of water for growth as compared with low-population density plants. Irrigation throughout the growing season delayed the fruit maturity. On the other hand, high-population density advanced maturity.

*Seed vigor acquisition.* Seed vigor acquisition as affected by weed competition at various stages of tomato seed development was studied. The conclusion derived from this 3 yr study was that weedy treatments which significantly suppressed tomato yield actually increased the percentage of tomato seeds with high vigor. This result likely suggests that under conditions of severe competition, tomato seeds of all the plant parts appear to have the highest priority for growth substrates.

*Weed competition.* The yield of transplanted tomatoes was negatively correlated with weed dry weight per unit area at harvest. Tomato yields from plots weeded only once, 36 days after transplanting, or 24 days after transplanting followed by a layby application of chloramben were not significantly reduced from weed-free plots. Sequential harvests showed that transplanted tomatoes entered the exponential growth phase approximately 33 days after transplanting. In weed-infested plots the total dry weight of tomatoes and weeds combined, per unit area, was equal to that of tomatoes in weed-free plots throughout the growing season.

*Weed ecology.* Green pigweed (*Amaranthus powellii*) has recently become the most common pigweed species. Both green pigweed and smooth pigweed (*A. hybridus*) have a greater root, shoot, leaf, and seed dry weight at maturity than redroot pigweed (*A. retroflexus*), formerly the most common pigweed species. When the three species are grown together, green pigweed has the greatest competitive ability as measured by both biomass and numbers. The relative competitive ability of redroot pigweed when grown with lamb's-quarters or green foxtail depends upon soil pH, being greater at pH 7.5 but lower at pH 5.5.

*Yellow nut sedge development and control.* The control of yellow nut sedge, a perennial weed, by glyphosate and bentazon was studied in greenhouse and field trials. Although



bentazon is quite effective on juvenile tissue, the tubers produced from treated plants do not indicate any abnormalities in dormancy or sprouting characteristics. One application of bentazon will not prevent tuber formation but only delay or reduce the rate of production. Upon glyphosate treatment there is cessation of tuber initiation, necrosis of rhizome tips, and prevention of nascent tubers from maturing, as well as inhibition of sprouting of tubers which matured immediately prior to application. Application of glyphosate after final tomato harvest and prior to fall tillage may be beneficial.

The dormancy of yellow nut sedge tubers is altered by natural endogenous plant hormones and can be deepened by the exposure of tubers to cold, nonlethal temperatures. The presence of moisture offers protection to the tubers from freezing lethal temperatures.

Several biotypes of yellow nut sedge have been identified which vary in floral characteristics, leaf width, and seed, tuber, and shoot production, as well as in herbicide sensitivity.

Tuber production occurs almost exclusively in the top 30 cm of soil, with 60% in the top 10 cm. Destruction of a yellow nut sedge plant by harrowing may give rise to fragmented plant parts. The rhizomes of this plant do not regenerate new plants, unlike rhizomes of quack grass.

## Greenhouse vegetables

### Cucumber

*Breeding and testing.* Through backcrossing and outcrossing and growing out larger segregating populations, the linkage was broken between dull fruit and resistance to powdery mildew, *Sphaerotheca fuliginea* (Schlect. ex Fr.) Poll. This has made possible the combination of tolerance to cucumber mosaic virus and powdery mildew in seedless lines that bear glossy and bitterfree fruits.

*Mite control.* Populations of two-spotted mites from different greenhouses varied in their resistance to common acaricides. Mites from the Harrow Research Station were controlled with cyhexatin, oxythioquinox, and Pentac (Hooker Chemicals).

The predacious mite *Phytoseiulus persimilis* Athias-Henriot provided reasonable mite control in demonstration greenhouses until June, when conditions favored the mites.

## Tomatoes

*Fusarium foot and root rot.* Early steaming (August–September) followed by lettuce, and late steaming (December) followed by planting in January, resulted in 13% infected plants in the early-steamed plots compared to 56% in the late-steamed ones. Combined foot and root rot ratings (0–5 scale) were 0.17 and 1.35, respectively.

Screening of material continued for Dr. E. A. Kerr's breeding program at the Horticultural Institute of Ontario, Simcoe.

## Tree fruits

### Apples and pears

*Fire blight.* Field inoculation experiments using nine local isolates of *Erwinia amylovora* (the causal agent of fire blight) on actively growing shoots of mature apple and pear trees, chosen for their range of susceptibilities, showed no distinct differences in their pathogenicity.

Controlled inoculation studies in the field over two successive seasons showed that the size-controlling apple rootstocks M26, MM106, and MM111 did not greatly influence the fire blight susceptibility of several popular scions budded onto them. Although a small significant interaction between scion cultivar and rootstock was observed, it was not large enough to overcome the strong influence of the cultivar itself on the fire blight susceptibility of young trees.

### Apricot

*Breeding.* A new cultivar named Harogem, formerly tested as HW405, was introduced in 1979. This is a mid- to late-season cultivar with exceptionally attractive, medium-sized fruit with very firm flesh of high quality, best suited for the fresh market. It has a good level of cold hardiness combined with adequate resistance to brown rot, *Monilia fructicola* (Wint.) Honey, and perennial canker, *Leucostoma* spp. The fruits do not drop readily even when fully ripe and resist cracking after heavy rains. Several selections now fruiting in regional trials, especially HW407, HW410, and HW425, offer sufficient promise that further releases are expected soon.

## Nectarine

*Breeding.* In 1979, controlled freezing tests were conducted with five progenies from crosses made in 1973 and their parents. None of the F<sub>1</sub> seedlings were hardier than the hardy parent but 10–48% were as hardy as the hardy parent. Two selections were propagated for entry in regional trials in 1980, namely HW103 and HW104. Both selections appear to have much improved appearance, size, firmness, and quality combined with adequate hardiness and disease tolerance.

## Peaches

*Breeding.* Two progenies in which H523 was used as the ancestral source of flesh firmness segregated for four flavor types: high sugar + high acid, high sugar + low acid, low sugar + high acid, and low sugar + low acid. Eleven new selections were made that have the proper flavor balance combined with very firm, nonoxidizing flesh and will be tested for cold hardiness, processing ability, and other characters next year.

Several very promising early-, mid-, and late-season selections for the fresh market were advanced into regional trials, and two canning clingstone selections with superior quality and resistance to bacterial spot, *Xanthomonas pruni* (E.F. Sm.) Dows., than Babygold 5 have been propagated for regional trials.

*Canker.* Larvae of the lesser peach tree borer, *Synanthedon pictipes* (Grote and Robinson), were found to be active in a majority of peach cankers surveyed. The larvae carried the canker fungi *Leucocytophora cincta* (Sacc.) Hohn. and *L. leucostoma* (Pers.) Hohn. In an experimental setup, application of special sprays recommended for the borer control not only reduced the number of the borer-infested cankers in the important trunk and scaffold area, but also resulted in increased number of healed cankers in the following year.

*Irrigation schedules.* Irrigation schedules based on climatological data were almost identical to those based on measurement of soil moisture with a neutron probe. Daily inputs required for climate-based irrigation schedules are maximum and minimum air temperatures, sunshine duration, and rainfall and are available from local weather data. The simple climate-based irrigation schedules can be used to accurately predict the optimum

time and amount of irrigation water a crop requires for maximum yields, thereby increasing the potential net returns to the grower.

Marketable yields during the first 7 yr of growth were increased by 9% as the result of supplemental irrigation. The highest tree density (536 trees per hectare) outyielded traditional spacings (266 trees per hectare) by 74% while intermediate density (358 trees per hectare) outyielded traditional spacings by 32%. High density also outyielded medium density treatments by 31%. Neither irrigation nor density treatments adversely affected cold hardiness, disease incidence, or fruit quality.

Measurement of available soil moisture from depths of 20 to 277.5 cm during the growing season indicated that as the season progressed and as soil moisture in unirrigated plots was depleted in the upper soil horizon, a greater proportion of the water requirement of the trees was met by withdrawal of water from below 180 cm. Irrigated trees used water stored in the soil horizons above 180 cm. This result also suggested that the root systems in 7 yr old trees in unirrigated plots were able to exploit soil moisture reserves near the water table. They were unable to do so earlier, when trees were younger and the root systems were less well developed.

*Orchard management.* A trial of four hedgerow systems was terminated in its 11th year. Highest cumulative yields were obtained with the oblique fan hedgerow at a density of 448 trees per hectare in which component trees were 3 m high and 1.5 m wide. This system outyielded by 35% a more conventional open centered system in which the component trees were 3 m high and 3 m wide and were at a density of 383 trees per hectare. The second-best system was the central leader hedgerow in which the trees were at a density of 536 trees per hectare and component trees were 3 m high and 3 m wide. The central leader system outyielded the check by 20%. The canted oblique fan system at a density of 746 trees per hectare with component trees being 3 m high and 2 m wide outyielded the check by only 2%.

*Peach X-disease vectors.* Two leafhopper vectors, in addition to the five species already known from the Ruthven outbreak area, have been identified. Adults of *Scaphoideus titanus* Ball and *S. melanotus* Osborn were trapped in flight from late July to early

October and in the month of August, respectively, both species going through one generation per year and being most numerous in the 3rd wk of August. The vector species and six harmless *Scaphoideus* species were principally found in a woodlot with diseased chokecherry bushes, but a few adults dispersed into a peach orchard at the end of the flight period.

*Weed control.* Good broad-leaved and annual grass control was achieved with preemergence application of granular simazine plus oryzalin, but no increase in tree growth as measured from trunk diameter was noted. Treatments with granular simazine plus oxadiazon did not control annual grasses, and simazine plus napropamide failed to control broad-leaved weeds. Periodic weed counts throughout the growing season indicated germinated weeds were controlled up to July. This suggested that the failure to measure an increase in tree trunk diameter was due to weed escapes from germinated but unemerged weeds prior to herbicide application instead of herbicide injury to the trees. The results indicate that full benefit of preemergence herbicides may not be realized

if herbicide application is not immediately preceded by cultivation.

## MISCELLANEOUS

### Grape crown gall

The "vinifera" grape cultivars Pinot Chardonnay, Gamay Beaujolais, and Riesling showed heavy incidence of aerial galls, often associated with mortality, in some Ontario vineyards. The disease was confirmed to be crown gall. Morphological, physiological and biochemical, and pathogenicity tests showed that the grape crown gall organism, *Agrobacterium radiobacter* pv. *tumefaciens* (Sm. & Towns. 1907) Kerr *et al.* 1978, belongs to a new biotype other than those affecting stone fruits and apple.

### Deep tillage of soils

Analysis of a depth of plowing experiment at Woodslee by climatically similar seasons indicated that deep plowing had no beneficial effects on soil compaction in the years in which a reduction was most needed. Climatic factors determined soil tilth and condition. There appears to be no justification for the input in equipment and energy required for deep tillage.

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# Research Station

## Ottawa, Ontario

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### Departures

H. BAENZIGER, Ing. Agr., M.Sc., Ph.D. Transferred April 1979	Legume breeding
I. A. DE LA ROCHE, B.Sc., M.Sc., Ph.D. Transferred April 1979	Head of Section; Tissue culture genetics
W. B. TOWILL, B.S.A. Transferred May 1979	Superintendent, Experimental Farm, Thunder Bay, Ont.



## VISITING SCIENTIST

C. NAKAMURA, B.Sc., M.Sc., Ph.D.

1979-1980 Cereal tissue culture

*Graduate students*

G. DOUGLAS, B.Sc. (Agr.)

Somatic hybridization

S. GLEDDIE, B.Sc.

Somatic hybridization

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<sup>1</sup>On educational leave, Guelph University, Guelph, Ont., from September 1979 to August 1980.

## INTRODUCTION

The Ottawa Research Station is the major center for plant breeding in eastern and central Ontario as well as for western Quebec. It is the major center for ornamentals research in the Research Branch. Canadian plant gene resources is a national program and a small unit is engaged in studies of honey bee behavior and pathology. In addition the Station is charged with numerous service functions and the management of the entire Central Experimental Farm.

The breeding programs are supported by multidisciplinary research including plant genetics and somatic cell genetics, cytogenetics, plant physiology and pathology, entomology, cytochemistry and morphogenetics, and weed science. Agronomy provides important information for improved crop management and a Quality Laboratory is servicing all the breeding programs. The scope of landscape architecture includes the beautification of the campus, the planning of the annual chrysanthemum show, and landscape planning for Agriculture Canada buildings across the country.

The Experimental Farm at Kapuskasing continues to conduct experiments on crop production and on beef-cattle management for northwestern Quebec and northeastern Ontario. The Experimental Farm at Thunder Bay is engaged in crop production for northwestern Ontario.

One of the more outstanding accomplishments in 1979 was the licensing of the soybean Maple Presto, the first truly short-season cultivar. Two short-season corn hybrids were licensed and two winter wheats and an early timothy reached the licensing stage. A new winter-hardy rose, David Thompson, was registered and two ornamental shrubs were released. Another highlight was the production and characterization of tobacco parasexual hybrids derived from fused protoplasts of the cultivated tobacco and *Nicotiana rustica*.

Mr. Bill Towill was transferred as Superintendent to the Indian Head Experimental Farm of the Regina Research Station in May. During his 19 yr of service at Thunder Bay, he provided excellent service to the Research Branch and his knowledge and experience were much appreciated by the farming community in northwestern Ontario.

This report summarizes some of the more important research results from the Station in 1979. Further information can be obtained from the publications listed at the end of this report. Reprints of the research publications and copies of this report are available on request from the Ottawa Research Station, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Tibor Rajhathy  
Director

## CEREAL CROPS

### Wheat

**Breeding.** Line 0-45-4, a soft white winter wheat, performed superbly in the Ontario cooperative winter wheat test for the 3rd yr in a row. In 1979 it outyielded Fredrick by 6.9% and Yorkstar by 5.7%. It has better pastry quality than Fredrick because of its lower protein content. It shares with Yorkstar the weakness of low hectolitre weight. Breeder seed was seeded on 1.6 ha in the fall of 1979 and the new cultivar is expected to be released to seed growers in the fall of 1980.

Another Ottawa winter wheat, T 1365-216, looks promising as a feed wheat for Eastern Canada, particularly the Maritimes. During 4

yr in the Eastern cooperative winter feed wheat test it outyielded Lennox by 1.6% while during 3 yr in the Maritime regional test it outyielded Lennox by 3.6%. Its performance is more consistent than that of Lennox, perhaps because of its greater winterhardiness.

### Barley

**Breeding.** The cultivar Massey, released in 1978, maintained its position as the highest yielding six-rowed feed barley in Ontario over 1977-1979. It was followed by its predecessor, Vanier, an Ottawa cultivar released in 1972. OB 294-1, a Trent × Vanier derivative, was by far the highest yielding strain in advanced tests grown in Eastern Canada.

Short-stawed selections in the testing program outyielded conventional tall types for the first time in 1979. Other specialized genetic material such as two-rowed and high-protein selections, lines of winter × spring origin, large-seeded lines, and hooded forage-type selections performed well.

## Oats

**Breeding.** In 1967, ORS began a program to increase the adaptability of oats by combining the daylength insensitivity (DI) genes in *Avena byzantina* C. Koch (CAV2700) from Turkey with all the desirable genes present in adapted Canadian cultivars. This task has been accomplished, but superior DI strains flower too early in Canada to produce yields equal to sensitive cultivars. Through breeding and selecting for lateness under Canadian conditions, high yielding DI strains have now been isolated. Two of these strains (OA 338 and OA 366) are now in advanced tests and they combine high yield with early maturity; lodging resistance; resistance for barley yellow dwarf, red leaf, and smut; white seed; large seed size; thin hulls; and high dehulling yields. A notable feature of almost all the DI genetic stocks is large seed size. DI strains flower earlier than daylight-sensitive strains and fill their seed over a longer period of time. Seed sizes of hulled strains vary from 35 to 45 mg per seed, whereas hull-less strains vary from 30 to 42 mg per seed. Large oat seed, comparable in weight to barley seed, is desirable to improve harvestable yields from combine harvesting. This is especially true when oats are grown in mixture with barley. Approximately 50% of Ontario small-grain cropland is sown to mixed grains.

A major advance has been made in the hull-less breeding program by the isolation of a large-seeded strain (PGR8646) whose groats possess few surface hairs (trichomes). Surface hairs break off the kernel during threshing and cleaning and they act as skin and respiratory irritants to handlers. This characteristic has reduced acceptance of hull-less cultivars in the past, but the availability of PGR8646 may lead to renewed producer interest and stimulate increased effort in breeding hull-less oats.

A new dormoat strain, PGR8658, has been isolated and seed supplies have been increased for technology transfer programs in Ontario and Alberta. This strain represents the best combination of the genes governing seed

after-ripening, winterhardiness, and spring germination of any dormoat strain selected to date.

## Physiology and morphogenesis

Progress has continued in the identification of important reserves in cereal grains with the development of several specific fluorescence tests for protein, starch,  $\beta$ -glucans, vitamins, phenolic compounds, and other constituents. In particular, a comprehensive chemical and microscopic study of wheat storage lipids showed dramatic differences in both the concentration and distribution of neutral lipids in the starchy endosperm of several different wheat cultivars. Development of fluorescence methods for assaying niacin, aromatic amine, and phytin deposits in cereal bran were also completed and comparative analyses showed considerable variation in the distribution of these compounds in wheat, oats, barley, and sorghum.

## Pathology

Septoria leaf blotch or black stem (*Septoria avenae* Frank f. sp. *avenae*) is a serious disease of oats in Eastern Canada. Some nonadapted cultivars have been identified in field tests as more resistant than others, but the transfer of this resistance to improved cultivars has not been possible. Inoculation of seedling plants with the disease-inducing organism is not correlated very well with the incidence and expression of the disease on adult plants in the field. A new technique has been devised properly to infect and identify resistant and susceptible adult plants under growth room conditions.

Damage to winter wheat crops in eastern and central Ontario from snow molds was less severe than in 1978. However, light to severe damage, primarily from abiotic factors in the central area and from snow molds in the eastern area, occurred in most fields surveyed. Pathogenic fungi involved in snow mold included *Fusarium nivale* "Fr." Ces., *Typhula* spp., and possibly *Sclerotinia borealis* Bubák & Vleugel. Test plots were established to assess the survival ability of wheat cultivars at five locations in the Ottawa Valley.

## CROP LOSS ASSESSMENT

### The delta race of bean anthracnose

The delta race appeared late in 1976 in Ontario, its first appearance in Canada. In 1977 the disease reached epiphytotic proportions, infecting approximately 25% of pedigreed bean fields in Ontario. At that time, strict quarantine measures were imposed and all infected pedigreed seed was rejected for further pedigreed status. As well, research into chemical seed treatments was initiated immediately. In 1978, seed treatments that had effectively controlled anthracnose in greenhouse trials were applied to all pedigreed seed stocks for field use. The combination of dry weather and effective seed treatments resulted in complete control of anthracnose. Further greenhouse and field tests were carried out in 1978 and 1979 using benomyl or benomyl-related compounds in combination with captan for protection against seed decay organisms and diazinon for protection against seed corn maggot. Once again seed-borne anthracnose was controlled. In 1979, optimum conditions prevailed for anthracnose infection in eastern and southwestern Ontario. Although six fields infected with anthracnose were located in southwestern Ontario, all cases were caused by soil-borne infection due to improper crop rotation practices. Seed treatments were effective in a year that was optimum for the disease.

Although seed treatments have controlled the disease for the present, resistant cultivars would be a more permanent control. Research into this area is being carried out at a number of establishments in Ontario.

### Ethephon to increase yield of soybeans

Field research was conducted in 1979 to determine if foliar application of the growth regulator ethephon would increase the yield of the Maple Arrow soybean cultivar. This study was undertaken in response to recent research in the United States which showed that ethephon application increased the yields of certain soybean cultivars. The ethephon was applied at rates of 0.28 and 0.56 kg/ha when the soybeans were at the first bloom, at 50% bloom, or at the first pod stage of growth. It was found that ethephon had no significant effect on soybean yield after application at either the rates or the stages of growth used in this study. None of the ethephon treatments

used were observed to cause a visible growth effect on the soybeans.

### Soil survival structures of *Phytophthora megasperma* Drechsl. and their role in primary infection of *Medicago sativa* L.

A hitherto-unreported existence of chlamydospores of *P. megasperma* Drechsl., the cause of alfalfa (*M. sativa* L.) root rot, as soil survival and primary infection units has been demonstrated. The chlamydospores originated from hyphal swellings and thalloid mycelium; these were usually round (8–16  $\mu\text{m}$  diam), hyaline, thin-walled, and germinated by one or more germ tubes which penetrated alfalfa tissues and ramified inside producing more chlamydospores, oospores, and sporogenous hyphae; the latter emerged from tissues to bear sporangia externally in the presence of sufficient water.

## CYTOGENETICS

### Cytology

*Wide crosses in cereals.* In addition to reciprocal intergeneric hybrids obtained from intercrossing Betzes barley with Chinese Spring wheat, barley-wheat hybrids (and frequencies) were obtained from crossing Emir  $\times$  Chinese Spring (0.60), Bonus  $\times$  Chinese Spring (0.40), Betzes  $\times$  Koga (0.29), and Bonus  $\times$  Koga (0.29). All hybrids were vegetatively vigorous but sterile and the phenotype was characteristic of the particular wheat parent.

Viable intergeneric hybrids were produced by crossing Bomi barley with Petkus rye. The phenotype of the rye parent predominated but the nucleolar organizers of rye were suppressed by those of barley. A total lack of chromosome pairing at meiosis implied no homeology between chromosomes of the two parents.

Trigeneric hybrids were obtained repeatedly by crossing Prolific rye onto barley  $\times$  wheat hybrids. Rye pollen with and without B chromosomes yielded seeds at frequencies of 0.63 and 1.81% of pollinated florets on the barley  $\times$  wheat hybrids. The hybrids had the expected chromosome number of 35 and the rye chromosomes were distinguishable by their larger size and presence of terminal C bands.

*Hordeum gene pool.* To evaluate the potential genetic resources of the wild grass-like

species, 1783 accessions (including 361 *H. bulbosum* L., 193 *H. leporinum* Link, 53 *H. murinum* L., 12 *H. bogdanii* Wil., 6 *H. brevisubulatum* Link, and 18 *H. violaceum* Boiss. & Huet) collected in Turkey, Greece, Iran, Chile, and Argentina have been planted and studied for chromosome number and morphology, fertility, and seed increase. The South American part of the collection includes 29 species, many of which are apparently new species not previously available for cytogenetic or morphological studies.

**Bromegrass.** The chromosome number of meadow bromegrass, *Bromus riparius* Rehm., is  $2n = 10x = 70$ . Meiotic chromosome pairing suggests a segmental allopolyploid origin.

Fertility is partially restored in the amphiploid of  $2n = 28$  *B. pumpellianus* ssp. *dicksonii* Mitchell and Wilton  $\times$   $2n = 28$  *B. inermis* Leyss. Therefore the sterility of the  $F_1$  tetraploid hybrid was largely chromosomal.

The first hybrids between Old and New World species of *Bromus* section *Pnigma* (Bromopsis) were produced from  $2n = 28$  *B. pacificus* Shear  $\times$   $2n = 28$  *B. benekenii* (Lange) Trimen and *B. pacificus*  $\times$  *B. riparius*. Attempts to hybridize *B. inermis* to the New World species have failed, but it can be crossed to both *B. benekenii* and *B. riparius*.

### Experimental haploidy and somatic cell genetics

**Brassica spp.** Haploid plants have been obtained in *B. campestris* L. (summer turnip rape), *B. napus* L. (rutabaga, winter and summer rapeseed), and *B. oleracea* L. (broccoli, marrowstem kale) by induction of microspore embryogenesis in cultured anthers. The frequency of haploid embryo formation was greatly stimulated by initially culturing the anthers at elevated temperatures (30, 35°C) prior to maintenance at 25°C. More than 2000 anther-derived plantlets have been regenerated.

Donor growth conditions such as temperature, photoperiod, and light intensity affected haploid plant yield obtained during subsequent anther culture. Optimal conditions for growing responsive *B. campestris* and *B. napus* anther donors in growth chambers were identified.

**Nicotiana.** Protoplasts isolated from cell cultures of chlorophyll deficient strains of *N. tabacum* and *N. rustica* were fused by a treatment with polyethylene glycol. More

than 200 green cell colonies were identified in the postfusion cultures and plant regeneration was induced in 30 different colonies. Cytological, morphological, and isoenzyme analysis of 25 lines provided conclusive evidence that all the regenerates were somatic hybrids. The chromosome numbers of the hybrids varied from 65 to the expected number of 96. Although some of the hybrids shed pollen, all were self-sterile in greenhouse conditions.

**Flax.** Haploid-diploid twin seedlings occur spontaneously in the cultivar Rocket 4. At meiosis in haploids the chromosomes undergo one meiotic division, divide irregularly, or are precocious in distribution. Haploids, as maternal parents in haploid  $\times$  diploid crosses, differ in seed set (5–46%) and in the frequency of diploid (58%), aneuploid (20%), and triploid (22%) plants among the  $F_1$  progenies. Segregation in the  $F_2$  provides evidence that haploid  $\times$  diploid crosses offer a method for obtaining diploid hybrids. Haploid-diploid twins with the fiber trait were identified in  $F_2$  families from crossing haploid Rocket  $\times$  diploid Natasja (fiber type). Rust-resistant twins were recovered in  $F_2$  families when Dufferin (rust-resistant) was used as the diploid donor in haploid  $\times$  diploid crosses. Reciprocal crosses between the two types of twins are expected to produce rust-resistant fiber type hybrids for plant breeding evaluation.

**Wheat.** More than 20 000 anthers were utilized in studies of factors (genotype, microspore development, and culture environment) influencing the in vitro production of haploid wheat. While three embryos were obtained from two Pitic-62 anthers, a significant stimulation of growth was not obtained in the treatments evaluated.

**Rye.** Delayed pollination of rye (spring type and self-compatible) with X-rayed pollen in combination with heat shock and cold shock treatment did not result in the production of haploid seedlings among the excised embryos.

## ENTOMOLOGY

### Population dynamics and pest management

**Alfalfa weevil.** Disease caused by the fungus *Entomophthora phytonomi* Arthur continued to govern intrageneration survival of alfalfa weevil, *Hypera postica* (Gyll.), across Ontario during 1979. However, life table studies in the Quinte area showed that

numbers surviving to adulthood were above normal and that many of these were attacked by *Microctonus aethioides* (Loan), a European parasitoid recolonized from the north-eastern United States during the early seventies. Studies showed that the Canadian biotype is bivoltine and that it truncates weevil egg laying in early spring by parasitic castration; this is a unique habit that confers additional benefit to biological control. Studies showed that the parasitoid is well adapted to our climate and has the capacity to damp weevil populations by killing a high proportion of those individuals that escape disease in the juvenile stages. Extensive surveys showed that *M. aethioides* has become established throughout southern Ontario.

*Alfalfa blotch leafminer.* Studies toward the design of a system for estimating field populations of the eggs and larvae showed that differences between alfalfa stems comprise the principal source of sampling variation and that numbers therein increase exponentially from base to tip. Taking these patterns and the costs of sampling into account, it was found that a systematic sample of four leaves per stem is the most appropriate sample unit. On this basis, 200 stems per field will give excellent precision for population estimates. However, the propensity of the leafminer to prefer the middle leaflet to the basal leaflets in a 3:4:3 ratio was exploited in the final sampling design. A comparison of this scheme to intensive sampling showed that population estimates were identical while sampling costs were reduced by four-fifths.

*Cereal leaf beetle.* A comparison of fitness in North American and European populations of *Oulema melanopus* (L.) supported the suggestion that a more vigorous strain of the beetle may have developed in North America following its introduction. Under controlled conditions the former insects were more fecund and after 10 mo of cold storage they oviposited over a longer period. Duration of the egg stage at five constant temperatures was identical in both populations but larval development differed significantly at 17 and 31°C, suggesting adaptation to different temperature ranges in the two populations.

## Honey bees

*Behavior.* Worker bees learn to distinguish between their own and foreign queens on the basis of individual characteristics. An odoriferous characteristic, such as shellac paint marking on the queen's thorax, was used by the workers to recognize their own queen. However, a tactile physical characteristic of a queen, such as clipped wings, was not used for recognition. Colony odors acquired from the hive environment also played a role in queen discrimination. Moreover, when the queens were removed from swarms, and each swarm was presented with a choice of two foreign queens, the queenless workers preferred the one which was more similar in age and reproductive status to their original queen. Recognition of pheromone was shown to account for this ability in the worker bees.

*Disease.* Continuing studies of *Ascosphaera apis*, the causal organism of chalkbrood disease, showed that sporulated cultures are rapidly killed by exposure to vapors of geraniol or citral, two naturally occurring compounds in the scent glands of the honey bee. Dead larvae were also disinfected by exposure to the two compounds, but at a slower rate than in the cultures because of reduced penetration. These same cadavers were rapidly sterilized by fumigation with ethylene oxide at concentrations recommended for disinfection of American foulbrood disease.

Laboratory tests for disease were accelerated and improved by a new method of detecting bacterial and microsporidian spores in bee and honey samples. Using continuous flow centrifugation, this procedure facilitates the recovery of low numbers of spores which are not detectable by other assays.

## FORAGE CROPS

### Grasses

*Timothy.* The breeding emphasis has been on providing new cultivars, with a wide range of maturity, high forage and seed yield, and increasing percentages of digestibility and protein content. We have applied for a license for a new early cultivar named Salvo; it was bred in direct response to farmers' demand. It will be used in Ontario and Quebec for mixtures with alfalfa and in the Atlantic region for early haylage. It is a pasture type with high aftermath. Two new wide-leaved

Labelle strains exceeded Climax in yield in Ontario.

*Orchardgrass.* The breeding program emphasizes high yields of forage and seed and late maturity. Two strains, reselected from Kay, produced well in the first harvest year in Ontario. A reselection of Rideau was entered in the provincial test in 1979.

*Bromegrass.* Tempo bromegrass has provided increased area of brome cultivation due to its highly successful seed production potential. New interspecific hybrids of *B. inermis* are being evaluated in spaced nursery rows.

### **Alfalfa**

The main breeding problems have centered on yield, *Phytophthora* resistance, selection for increased protein, and studies relating to the economic effects of harmful insects. Four synthetics with considerable tolerance to *Phytophthora megasperma* Drechsl. have been established in the field. Four polycross lines for high protein were established in the field for yield evaluation.

*Breeding methods.* Twelve promising F<sub>1</sub> progenies, selected for high seed setting from crosses between Iroquois and Thor, differed in mean and variance. Some families were characterized by a high mean and a small variance, whereas some other families were characterized by a relatively low mean and a large variance. The latter observation was often associated with an unequal parental performance. High mean and small variance can be hypothesized to indicate a genetic situation where tetraallelic or near tetraallelic systems predominate in those families. Half-sib and unrelated matings were compared using either a single or a mixed source of pollen. Maximum seed setting (7.1 seeds per pod) was obtained when a mixed source of pollen was used in unrelated matings. When half-sibs were substituted for unrelated matings, seed setting decreased by 13% with the use of mixed pollen, and by 15% in the case of single crosses.

### **Corn**

*Breeding and genetics.* Two new experimental hybrids qualified for licensing in provincial corn committee tests, OX623 in Ontario and OX543 in the Atlantic Provinces. OX543 is the third hybrid developed in this program that is currently qualified for inclusion on the Atlantic Provinces' recommended

list. Eighteen inbred lines were released for general distribution through the Plant Gene Resources office. The main breeding effort continues to be an upgrading of root strength and stalk quality in 2100–2800 heat-unit inbred lines previously developed in this program. A study of heritability of root strength in corn was begun. Equipment to measure the kilograms of pull required to break the roots of corn plants was developed and tested. Six inbred lines used as vehicles in this development work gave readings ranging from a low of 370 kg for CO125 to a high of 863 kg for CO258. A collection of cool-temperature-tolerant inbred lines was made mainly from northwest European sources.

*Agronomy.* In a continuing experiment with corn and sorghum, alone and in mixtures, two forage sorghum hybrids were grown in all combinations of mixtures in the row and between rows of early-, medium-, and late-maturing corn hybrids. Each year some mixtures both within and between rows yielded more silage dry matter than either corn or sorghum alone. At harvest the sorghums averaged only 21.5% dry matter compared to 30.8% for the corn hybrids. The sorghum hybrids were much lower in digestibility, averaging only 50.9% compared to 66.0% for the corn hybrids. The corn hybrids alone averaged higher in digestible dry matter than either sorghum alone or sorghum mixtures.

### **Soybeans**

*Breeding.* The cultivar Maple Presto (line BD21117) was licensed in 1979 and seed distributed through the SeCan Association. It is the earliest licensed cultivar in Canada, maturing 12–16 days before Portage and with as few as 2000 heat units. Yields obtained by seed growers in Prince Edward Island, Ontario, and Manitoba have been satisfactory for a cultivar that matures so early. The cultivar Maple Arrow has gained wide acceptance by producers in eastern and central Ontario. The line AU-313, of intermediate (Portage) maturity, has been tested regionally for 3 yr, and performed very well; seed supplies will be increased in 1980. Five small-seeded (less than 6 mm diam) lines for the Japanese natto market were grown in 0.4 ha plots and 100 kg of seed of each sent to Japan for quality evaluation. They were also in the regional trial for yield and maturity assessment. The backcrossing program to transfer

daylength insensitivity to the cultivar Harosoy indicates that the gene involved differs from that studied elsewhere. It influences only flowering, not both flowering and pod development. Four backcrosses to incorporate the high-podded characteristic in Maple Arrow and Maple Presto have been completed. The greater height above the soil of the lowest pods in the selected lines is associated with a taller plant (20 cm) and about 5–7 days delay in maturity.

*Agronomy.* Nine soybean cultivars ranging in maturity from the earliest available to ones rated to require 2700 heat units were compared in narrow (18 cm) and wide (36 cm) row spacing. Every cultivar yielded significantly more in narrow row planting, but differences were not directly related to maturity rating. Both the earliest and the latest cultivars yielded 23% more in narrow rows. Other differences ranged from 5 to 27% while the average increase due to closer planting was 16%. With adequate weed control it seems reasonable to expect good economic benefit to be gained from planting soybeans in narrow rows in this area.

### Pathology

An intensive survey of alfalfa fields with generally heavy clay soils in 13 Ontario counties showed that *Phytophthora megasperma* was present in about 4% of the fields in Renfrew, 8% in Perth, 25% in Brant and Dundas, 62% in Haldimand, and 75% in North Niagara. Also, 50% of the sampled alfalfa fields in Quebec were affected by *P. megasperma*. Thus, over the past 4 yr, 67 isolates of *P. megasperma* and one of *Phytophthora cactorum* (Leb. & Cohn) Schroet. were isolated from alfalfa fields in Ontario and Quebec. These isolates are classified into three definite forms: (1) small spored; (2) large spored; (3) large spored having a limited fruiting capacity producing oogonia in the presence of other *Phytophthora* species. Pathogenicity tests were done on a few isolates, and definite differences were observed in disease severity.

Using a one-isolate source (AR-2, highly pathogenic), inoculum potential studies, testing a standard concentration of 1× as well as 0× (control), 1/10×, 1/2×, and 2× concentrations (based on mycelial weights), indicated that highly significant differences in disease severity occurred between the highest concentrations, that is 2×, 1×, 1/2×, and

the lower concentration 1/10× and 0×. These results were determined on Saranac, a highly susceptible alfalfa cultivar, and Apollo, a resistant-type cultivar. Also, composite inoculum (11 pathogenic isolates) was tested and higher levels of phytophthora root rot were observed as compared to the one-isolate source, but they were not significantly different among 2×, 1×, 1/2×, and 1/10× concentrations.

## ORNAMENTALS

### Floriculture

Gibberellins were the most variable growth regulators in photoperiodically treated chrysanthemums. GA<sub>9</sub> was most prevalent and reached highest level in apices on the 20th short day (SD). In third and fifth leaf and bud tissues, GA<sub>9</sub> was more prevalent on 10th SD. GA's 1, 3, 4, and 7 were present in trace amounts. Morphactin changed the geotropical response and root growth substance content: IAA, ABA, GA<sub>9</sub>, and GA<sub>5</sub> contents decreased; IPyA, IAcA, GA<sub>3</sub>, and GA<sub>4</sub> contents were not affected; and ILA content increased with increasing dosages of morphactin. The growth substance pattern of decapped roots resembled that of the roots treated with the highest dose of morphactin.

Growing of chrysanthemums at split, cool night temperature was continued emphasizing the responses to temperature between the pot- and bench-grown plants. Work on production of roses at split, cool night t° and different soil t° is progressing. Requirements of *Hypoestes aristata* (Soland. ex R. Br.) and *Sinningia cardinalis* (Lehm.) as pot plants were determined, described, and supplied to trade. Determination of photosynthesis and respiration rates of chrysanthemums grown at different night temperatures were started to determine the physiological basis for varietal growth responses.

A range in germination rates was shown among *Impatiens wallerana* (Hook. F.) cultivars. Over the temperature range of 15–30°C, the fast-germinating cultivars showed strong temperature dependence and the slow-germinating ones showed minor responses to temperature. Continuous light enhanced germination, but response was relatively small and cultivar-specific. Correlation was demonstrated between the rate of germination and seedling establishment. Pretreatment of seeds at 8°C for 7 or 14 days and transfer to 25°C



increased rate of germination and facilitated subsequent seedling development and establishment. Seeds pretreated with polyethylene glycol (PEG) 6000 (-7.5 bar for 10 days) germinated within 24 h after release from osmotic control, resulting in rapid seedling development and establishment and earlier flowering. The PEG pretreatments were superior to low temperature pretreatments, but they are not readily applicable. Low temperature seed pretreatment can be utilized to improve seedling establishment in commercial production. Soil cover (0.5 cm Pro Mix A) significantly improved seedling establishment of both pretreated and nontreated seeds.

Flowering of *Impatiens* was strongly influenced by temperature. Flowering was less at lower (earlier) nodes and in larger numbers by plants grown at 15 than at 25°C. At 15°C, apical dominance was decreased resulting in growth of compact plants.

Floral buds were induced on excised leaf segments of the SD plant *Streptocarpus nobilis* (C. B. Clarke), but occurred in vitro only under conditions of SD.

### Entomology

Six compatible components were selected for integrated control of the twospotted mite, aphids, thrips, greenhouse whitefly, and sow bugs infesting roses. Techniques for rearing, shipping, and releasing the chalcid parasite *Encarsia formosa* (Gahan) and the predatory mite *Phytoseiulus persimilis* Athias-Henriot were developed. The efficacy and selectivity of methoprene and K oleate as pesticides of the greenhouse whitefly were determined. Selection of poinsettia from six cultivars partially resistant to the greenhouse whitefly was begun.

### Pathology

Tests with *Pythium aphanidermatum* (Edson) Fitzp. showed that the fungus would not grow in culture at pH 4.5 or lower. Soilless mixtures regulated to pH 4.5 supported satisfactory growth of poinsettia and inoculation with *P. aphanidermatum* failed to produce the disease. Poinsettia growth was best in soilless mixtures at pH 5.5-7.0 and maximum growth of *P. aphanidermatum* occurred at pH 5.5-6.5. Optimum temperature for growth of both host and pathogen was 30°C. In sterile soilless mixtures, addition of casein hydrolysate increased activity and persistence of *Trichoderma viride* Pers. and

two *Streptomyces* spp. antagonistic to *P. aphanidermatum*, giving protection against root rot of poinsettia over a 6 wk period.

A strain of *Pythium splendens* Braun was isolated from diseased *Chrysanthemum morifolium* (Ramat.) Hemsl. plants from a greenhouse at Ottawa; it caused severe blackening of the stems of chrysanthemum cuttings and produced blackleg in geranium. Two strains of *P. splendens*, one isolated from geranium and the other from Rieger begonia, failed to produce symptoms on chrysanthemum.

Twenty clones of *Poa annua* L. were tested for resistance to leaf spot caused by *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem. Differences in susceptibility to the disease were observed and six clones exhibited a high degree of resistance. Inoculation of 20 clones with a strain of *Colletotrichum graminicola* (Ces.) Wils. (anthracnose), prevalent on turfgrass in the Ottawa area, showed that at least two clones are quite tolerant of the fungus. No tolerance of blight caused by *P. aphanidermatum* was found among the 20 clones tested.

### Turf

Turfgrass introductions were field seeded and rated for color, quality, ground cover, and stand density; winterkill and disease infections were noted. Kentucky bluegrass cultivars Majestic, Bristol, Bonnie Blue, and Baron were the top-rated bluegrasses and Biljart, Highlight, and PP15E the best fescues. Tolerance of turf for winter-applied deicing compounds NaCl, CaCl<sub>2</sub>, and urea, at rates up to 40.5 kg/100 m<sup>2</sup> yearly, was tested. No damage to turf or buildup of salts in soil was evident.

A native fescue grown from seed, from a Maritime tidal flat, was more salt tolerant than other fescues and bluegrasses and superior to the cultivars Highlight, Biljart, and Carlawn, the new, improved fescues. In the field, this strain produced good seed yields and persisted better when clipped monthly than with frequent mowing. It would be a useful component of roadside turf mixtures subjected to winter salt sprays and receiving minimal mowing and maintenance in summer. Annual sampling of *Poa annua* from original sites and subsequent greenhouse growth tests showed that the perennial-like forms of the species are stable and uniform. Successful swards were obtained from spring

and fall seedlings in 1979 and provided good turf under minimum management.

Twenty selections of *Poa* and four bentgrasses were tested for resistance to common turf pathogens. Inoculation with leaf spot indicated several strains showing good resistance to *B. sorokiniana*. These *Poa* selections were far more resistant to this pathogen than the four bentgrasses under test.

### Plant breeding

A winter-hardy, repeatedly flowering, mildew- and black-spot-resistant hybrid of *R. rugosa* (Thunb.) named David Thompson was released for commercial production. Inoculations of 37 tetraploid and 15 diploid rose hybrids with three races of black spot, *Diplocarpon rosae* Wolf, showed resistance to each race in 11 diploid and two tetraploid hybrids. Black spot resistance in roses is rare, especially in hybrids which can be crossed more readily with garden cultivars than diploid roses.

One cultivar of *Forsythia* with improved flower bud hardiness, Spring Gold, was released jointly with the Research Station, Morden.

Several hardy, freely flowering seedlings of *Weigela* with a long flowering period, low growth habit, and attractiveness of flowers and shrubs are being evaluated at Ottawa. One seedling is being evaluated for its adaptability to different climatic conditions.

### Arboretum and plant evaluation

Evaluation trials on annual plants were continued: 160 cultivars of *Antirrhinum majus* (L.) and 213 of *Callistephus chinensis* (L.) were grown. Another 190 species and cultivars from 43 genera were grown and rated. Evaluation of alpine and herbaceous plants was continued. The collection of *Iris germanica* (L.) was revised with addition of several new remontant forms. Observations were continued on *Draba*, *Campanula*, *Hosta*, and *Primula*. Labeling was completed in the arboretum and campus areas with new trilingual labels. Some renovations were carried out on overgrown beds in the arboretum and other new plantings were made, particularly of the genus *Prunus*.

## PLANT GENE RESOURCES

### Plant Gene Resources Office

The functions of the Office have increased steadily since it was established by the Research Branch in 1970. Current activities include (1) the production of catalogs or inventories of plant gene resources maintained in individual working collections of Canadian plant breeders and other plant scientists; (2) the creation of computerized data banks on crops of economic importance in Canada; (3) the provision of a query service to plant breeders and others for locating genetic stocks and cultivars; (4) the preservation and maintenance of plant germ plasm; (5) national and international exchanges of genetic stocks and cultivars; (6) the participation, on Canada's behalf, in the program of the International Board for Plant Genetic Resources to establish a world network of gene banks for international seed storage of valuable germ plasm collections; and (7) the production of the *Plant Gene Resources of Canada Newsletter*.

### Conservation

With the acquisition in 1979 of an additional 27 m<sup>3</sup> of seed storage space with temperature and humidity control, the total long-term seed storage facilities at the Plant Gene Resources Office now include 54 m<sup>3</sup> at 4°C and 20% RH and 64 m<sup>3</sup> at -20°C with no humidity control. Seed of nearly 36 000 stocks of various plant species is preserved in these facilities.

### Exchanges

Activities of the Plant Gene Resources Office in connection with exchanges of genetic stocks and cultivars in 1979 involved 297 such exchanges with individuals in 38 countries for a total of almost 7000 accessions.

## EXPERIMENTAL FARM, KAPUSKASING, ONT.

### Legume inoculation and seed coating

The use of inoculants and seed coating on alfalfa and birdsfoot trefoil and seed coating on timothy has been under study since 1976. Dry matter yields of both Leo birdsfoot trefoil and WL-215 alfalfa were not statistically different when coated seeds or regular inoculant were used in this study.

## EXPERIMENTAL FARM, THUNDER BAY, ONT.

In 1977, another trial was established to compare six strains of alfalfa inoculants (obtained from Ste-Foy Research Station), coated seeds, coated seeds plus 20% regular inoculant, and noninoculated seeds of WL-215 alfalfa. The same treatments were done on Leo birdsfoot trefoil except for the six strains of inoculants. None of the six strains of inoculants proved to be superior to the regular commercial strain of alfalfa inoculum. WL-215 alfalfa yielded 5669 kg/ha without the bacterial culture and an average of 5792 kg/ha with inoculant. Leo birdsfoot trefoil yielded 5802 kg/ha with a regular strain of inoculant and 5804 kg/ha without inoculant. Seed coating of alfalfa did not result in significant yield increase, nor did a 20% increase of the seeding rate. A 20% higher seeding rate of Leo birdsfoot trefoil (coated seeds) did not increase yields significantly.

In 1978, two different types of seed coating and rates of seeding of Apollo alfalfa, Leo birdsfoot trefoil, and Toro timothy were studied. An early spring plant count of Apollo alfalfa produced 235.8 plants per square metre with the use of a regular inoculant and an average plant count of 175.5 per square metre with the two coatings. Similarly Leo birdsfoot trefoil had 186.3 plants per square metre without a seed coating and 150.3 plants per square metre with a coating. Toro timothy had the same response with 453.6 plants per square metre without a seed coating and 394.2 plants per square metre with a coating. A higher seeding rate of coated seed produced a similar plant count to the bare seeding. Dry matter yields of alfalfa were on the average 6311 kg/ha with coated seed and 6646 kg/ha with bare seed, 6806 kg/ha with coated birdsfoot trefoil and 6839 kg/ha with bare seed, and 6085 kg/ha with coated timothy and 6173 kg/ha with bare seed. No difference was noticed between the two types of coating.

In the spring of 1979, another trial was sown to look at three alfalfa cultivars, Apollo, Iroquois, and Vernal, coated with five different commercial materials at two seeding rates. A harvest in the year of seeding was taken and none of the different coatings resulted in a significant yield increase over the bare seeding with any of the cultivars. Seed coating of Vernal alfalfa resulted in slightly more plants per square metre, whereas with Apollo and Iroquois, the bare seeded plots had more plants per square metre than the different seed coatings.

### Crop management

*The effect of nitrogen on timothy and soil acidity.* With the use of urea (45-0-0), diammonium phosphate (18-46-0), and ammonium nitrate (34-0-0) at low, medium, and high rates of application, the largest crop response to the nitrogen carriers was obtained in the early season; diammonium phosphate was the most effective fertilizer at comparable rates of application on coarse-textured soils having a pH of 4.9. The use of lime at 4480 kg/ha in the fall of 1977 did not significantly increase total forage production over all treatments in 1978. Average production on unlimed soils having an average pH of 4.9 was 7415 kg/ha, compared to 7405 kg/ha on limed soils having a pH of 5.5. A comparison of urea with diammonium phosphate on limed plots showed the latter more effective. Unfertilized stands of timothy grown on soils having a pH of 5.2 produced only 2806 kg/ha of forage under a two-cut system. In comparison, on limed soils having a pH 6.2, total yields averaged 5204 kg/ha. The yield results for 1979 were only from one cut due to the lack of precipitation during the month of July. Plots that received low applications of fertilizers were completely taken over by white clover by the end of June. The plots that received medium and high rates of application of fertilizers, with no lime content, showed no significant difference in the dry matter yield, 4780 and 5137 kg/ha respectively. The plots that received medium and high rates of fertilizer with lime showed some difference in dry matter yield, 5911 and 5302 kg/ha respectively.

*Winter survival of red clover cultivars in northern Ontario.* This test including five cultivars of red clover (Lakeland, Ottawa, Florex, Redland, and Prosper-1) was seeded on 7 May 1977, and was sufficiently established by the fall of 1977 to harvest one crop in that year. The stand went into winter in excellent condition, but severe icing conditions in January 1978 caused severe winterkill. The cultivars Florex, Prosper-1, and Ottawa managed to survive, producing good yields. The total mean yield for the years 1977-1979 of the three cultivars was 7295 kg/ha. Now into their 3rd yr, the varieties

Florex and Prosper-1 continue to show persistence despite winter injury, and retain a

relatively good stand compared with Lakeland, Ottawa, and Redland.

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## INTRODUCTION

Integrated pest management (IPM) programs for apple and peach were again used extensively by Ontario growers. Tentiform leaf miner continued as a serious problem in apple orchards whether or not they were under IPM.

A predictive model was developed for carrot rust fly based upon heat units accumulated above 3°C which permits highly reliable date of adult emergence forecasts for both first and second generations.

Postplant application of the granular nematocides oxamyl, aldicarb, and phenamiphos, together with foliar applications of oxamyl, reduced nematode populations and allowed improved growth of young apple trees relative to the controls.

Alfalfa seed treated with oxamyl produced better seedlings than untreated seed in sterile soil, and the seedlings were protected from injury when infested with nematodes.

Tomato ringspot virus was identified in Chelois, Ventura, and Vincent grapevines; symptoms were cultivar specific. In addition, tobacco ringspot virus was identified in Pinot Chardonnay vines. The COPI contract established this year for developing a mother block of superior virus-tested vines is an important step forward for the industry.

Three scab-resistant apple cultivars, Britegold, Murray, and Trent, were named and released by Smithfield Experimental Farm. An early high-yielding tomato, Earlibright, was also named and released.

For more information on our research projects or for reprints of published papers, please write: Director, Research Station, Research Branch, Agriculture Canada, Vineland Station, Ont. L0R 2E0.

A. J. McGinnis  
Director

## PESTICIDES

### Application

*Evaluation of spray coverage.* Spray coverage, as evaluated by fluorescent dye deposits and phosmet residues, was correlated with mortalities of first instar oriental fruit moth, *Grapholitha molesta* (Busck), placed on field-sprayed peach foliage. High volumes per hectare resulted in the highest and most uniform coverage ratings. Residue deposits were highest at the highest application rates, but the relationship was not directly proportional. Likewise, mortality of larvae was higher throughout the test period at higher application rates. A residue decay-rate model, which incorporated several cumulative environmental factors, gave a better correlation than did an asymptotic regression model.

*Air cushion spray boom.* The design of the boom was refined to meet production require-

ments, and prototype units were distributed to potential licensees for evaluation, under a COPI contract. The machine shows real promise for large-scale herbicide applications where it can operate virtually independently of travel speed or wind conditions.

### Chemistry

*High-performance liquid-chromatographic method (HPLC) for benmyl and its persistence on apple foliage.* A simple, effective HPLC method was developed that permits residues of benmyl and its degradation compound, methyl 2-benzimidazole carbamate, to be determined simultaneously. The method was employed to study the persistence of benmyl on apple foliage after spray application. The analyses revealed that 50% of deposits dissipated in 5–8 days. For the first 10 days, however, more than half of the total residue present at any time consisted of intact benmyl. Consequently, when benmyl is reapplied the percentage of benmyl in the total residues will be even higher.

## INSECTS AND MITES

### Integrated pest management (IPM)

*Pest management in apple orchards.* The effect of insecticides used for pest control in integrated pest management programs on field populations of predators was studied in several apple orchards on the Niagara Peninsula. Generally, orchards sprayed with azinphosmethyl (50% WP, 0.3–1.0 kg/ha) and phosmet (50% WP, 1.1–2.6 kg/ha) had fewer predators than those in which no insecticides were applied. Eggs and immature stages of the predators were absent or in very low numbers in the treated orchards, indicating that they did not survive the insecticide treatments. Adults found in these blocks, therefore, were immigrants from adjacent untreated areas. In both sprayed and unsprayed orchards, however, predator numbers were low. The insecticide used and the available prey both had an effect on the predominant species surviving among different predator groups, especially the coccinellids and mirids.

*Pest management in peach orchards.* Controls for oriental fruit moth (OFM) were generally excellent in 1979. Timing insecticide application by using pheromone traps for oriental fruit moth and obliquebanded leafrollers has gained wide acceptance by growers and surveys indicate increasing usage of chemicals recommended in the IPM program. Plant bugs, mainly the tarnished plant bug, were a problem during the past two summers. Preliminary results suggest a correlation between fruit damage and drought at critical periods, along with lack of suitable alternate hosts including certain weeds. Studies on the lesser peachtree borer, *Synanthedon pictipes* (Grote & Robinson), showed up to three peak periods of activity. These peaks coincide closely with peak periods of OFM activity, suggesting that sprays for OFM control will also suppress lesser peachtree borer populations.

*Monitoring predator-prey interactions in orchards by serological methods.* Antigens of oriental fruit moth, codling moth, and obliquebanded leafroller larvae in the ground beetles *Amara*, *Harpalus*, and *Pterostichus* species were detected by cross-over electrophoresis on cellulose acetate strips up to 72 h after ingestion. Serological comparisons, however, revealed broad antigenic similarities

among species in five lepidopteran families (Tortricidae, Gracillariidae, Lasiocampidae, Geometridae, Noctuidae) found in apple orchards. These antisera also gave limited reactions with beetle antigens. Genus-specific antibodies, isolated by serum fractionation and cross-absorption, are needed to identify specific prey.

### Ecology

*Simulation model used as a predictive tool in mite control.* A simulation model for the European red mite, *Panonychus ulmi* (Koch), was tested as a predictive tool for warning fruitgrowers of potential mite problems. Mite population curves were generated for four climatic regions of Ontario: southwestern Ontario, Norfolk county, Niagara Peninsula, and Georgian Bay. The simulation model was run with actual weather data from each of the areas. The 2 wk predictions were based on 5-day-temperature forecasts plus 10 yr averages. Over the season seven predictions were provided to OMAF extension horticulturists in the four areas to forewarn them of the expected dates of rapid population increase. The predictions also indicated the optimum dates for application of acaricide if necessary. The prediction was generally more reliable for the first 7 days of each 2 wk period.

*Predictive model for the carrot rust fly.* A predictive model for the seasonal development of carrot rust fly was produced by first measuring insect development in the laboratory at five constant temperatures ranging from 10 to 20°C. Based on a threshold temperature of 3°C, egg hatch, larval development, pupation, and adult emergence required about 100, 450, 100, and 300 degree-days, respectively. A total of 1010 degree-days was required for continuous development from egg to adult. As the temperature drops below 15°, an increasing proportion of the pupating insects enter diapause. Diapause appears to be induced when exposure to low temperatures occurs in the prepupal stage. Weather and insect activity data collected from the Holland Marsh for 7 yr were analyzed and fitted into the predictive model. Results show that seasonal development of the carrot rust fly can be predicted very closely by summing degree-days above the 3°C threshold. The date of first adult emergence was predicted within an average of 3.4 days by using air temperature readings recorded on a Stevenson screen over a 7 yr period; that for 10%

emergence was predicted within 1.3 days. Soil temperatures allowed an even more accurate predictive index. Emergence of the first generation was predicted within an average of 1.5 days by using soil temperatures recorded at 5 cm; predicted date for 10% emergence varied from observed by less than a day. Predicted date of second-generation emergence was within an average of 1.7 days of the actual date when based on total accumulated degree-days, and within 1.2 days if based on degree-days accumulated after first emergence of the first generation.

### Chemical control

*Evaluation of acaricides and insecticides.* In laboratory studies, dicofol-resistant European red mites were shown to have a 10-fold cross-resistance to the experimental acaricide XE333 (Chevron Chemical Co.) and 3- and 4-fold cross-resistance to the pyrethroids cypermethrin and fenvalerate, respectively. The dicofol-resistant mites are also resistant to most organophosphorus compounds. The pyrethroids were all highly toxic to the predacious mite *Amblyseius fallacis*; in field tests, however, permethrin allowed some survivors. The acaricides XE333, CME 12301 (Celemerck, GMBH & Co.), and RO-12-0470 (Maag Agrochemicals) caused females of European red mite to lay sterile eggs. No cross-resistance to the latter two acaricides was apparent. The tentiform leaf miner, *Phyllonorycter blancardella* (Fab.), was a major problem in apple orchards, whether under IPM program or not. Permethrin 25% WP, 125 g/1000 L, with or without captafol provided excellent control at Jordan, Ont., when applied shortly after first eggs were deposited. A single treatment with methomyl 90% WP, 500 g/1000 L, was also effective when approximately 50% of the deposited eggs had hatched. Methomyl applied as late as when mines were first observed also provided good kill of larvae within the mines but necessitated extremely good coverage. Methomyl applied in late September greatly reduced the numbers of larvae that were preparing to pupate and overwinter in the leaves.

Pirimicarb, phosalone, and fenvalerate were the best of 10 products assessed for summer control of the green apple aphid, *Aphis pomi* (deGeer). On an infestation rating scale of 0–5, the average weekly ratings 4 wk after treatment were 0.16, 0.26, and

0.36 for pirimicarb, phosalone, and fenvalerate, respectively. Average weekly ratings for the standard, diazinon, and the check were 1.18 and 2.62, respectively. For the synthetic pyrethroids cypermethrin, HC13279 (Hoechst Canada Inc.), and permethrin, respectively, the ratings were 0.43, 0.45, and 0.47.

Sprays of permethrin, fenvalerate, or Morestan (Bayer AG) applied for control of first-generation psylla nymphs in pear orchards provided excellent initial knockdown with residual activity up to 5 wk for the latter two and 7 wk for permethrin. When the second-generation population was treated on 20 July, control was only maintained for 3 wk. Small numbers of pear rust mite, *Epitrimerus pyri*, and pearleaf blister mite, *Eriophyes pyri*, were found in all treated trees.

## NEMATODES

### Host-parasite relations

*Hosts of Pratylenchus neglectus, Pratylenchus projectus, and Helicotylenchus digonicus.* In greenhouse pot trials, bean, cucumber, and Kentucky blue grass were hosts of *P. neglectus* and *P. projectus*. Of the three nematodes only *P. projectus* thrived on pea. Kentucky blue grass was the only host for *H. digonicus*. Carrot, potato, and strawberry proved not to be hosts for the three nematodes tested. Bean and cucumber are new additions to the host lists of *P. neglectus* and *P. projectus*. Bean is recommended as a host for rearing large numbers of *P. projectus* and *P. neglectus*, whereas Kentucky blue grass is recommended for *H. digonicus*.

*Effect of age of alfalfa root on penetration by Pratylenchus penetrans.* Two day old tissue in the root hair zone was penetrated at twice the rate of 10 day old or 20 day old portions of the tap root. This difference was also observed in lateral roots and was not affected by the length of the incubation period, the temperature, or by increasing the number of nematodes from 1 to 10 per site. Females and third-stage larvae entered the root tissues, irrespective of age, at a rate of 122% and 83% faster, respectively, than did males. All life stages penetrated the youngest root tissue best. Age-related differences in the rate of penetration according to plant age were only significant with 3 wk old plants, not with younger seedlings.

*Screening rye cultivars and breeding lines for resistance to the root-lesion nematode Pratylenchus penetrans.* In greenhouse pot tests, 66 cultivars and breeding lines of rye were screened for resistance to the root-lesion nematode. Ten cultivars and breeding lines (DS 57-43, Pekka, Kings/Dakold, Sangaste/Dakold, Frontier, Kustovaja, Dankowskie Sztywne I, Dakold, WR5/Prolific, Lovaspotonia/Petkus/Dakold) supported less reproduction of the nematode than did Tetra Petkus, the standard cultivar used in rotation with flue-cured tobacco in southwestern Ontario.

### Control

*Chemical control of Pratylenchus penetrans in newly planted apple orchards.* The root lesion nematode, *P. penetrans*, has been suspected of causing poor growth of trees in newly planted apple orchards. Postplant granular applications of oxamyl, aldicarb, and phenamiphos (all at 0.8 kg/ha) were applied as 45 cm bands around the base of young apple trees (McIntosh on M26) for 3 yr consecutively. At the end of this period, the growth increases, relative to the untreated control, were 3, 22, and 2%, respectively, for the three materials. Four oversprays annually with oxamyl L. (1.12 kg/ha) increased tree growth appreciably: 16% in the untreated control and 17, 29, and 15%, respectively, for trees treated with the granular materials. Root populations of *P. penetrans* were reduced significantly after the 3 yr period by all treatments except oxamyl granular without the oversprays. Applications of aldicarb granular and oxamyl foliar offer promise in controlling this nematode and in promoting tree growth during the establishment period of young apple orchards.

*Treatment of alfalfa seed with a systemic nematocide.* The effect of the systemic nematocide, oxamyl, on germination of alfalfa seed (cv. Saranac) was tested by soaking the seed in aqueous solutions of oxamyl, drying, and then planting in sterile soil inoculated with *Rhizobium*. Four weeks after seeding, the best seedling stands were from seed soaked in aqueous oxamyl concentrations ranging from 4000 to 16 000 ppm; the largest seedlings developed from seed treated with oxamyl at concentrations of 4000 and 8000 ppm. Concentration of the oxamyl treatment had little effect on nodulation. Individual seedlings from each treatment were infested with a single female of the root-lesion nematode, *P.*

*penetrans*, to determine the efficacy of the oxamyl treatment. Severity of infection by *P. penetrans* was inversely related to the concentration of oxamyl treatment in the range of 2000 to 16 000 ppm; at 32 000 ppm no infection occurred.

## PLANT DISEASES

### Fruit crops

*Virus diseases of grapes.* Both components, middle (M) and bottom (B), of peach rosette mosaic (grape decline) virus contain a single protein with a molecular weight of 57 000 daltons. The average composition of nucleotides in moles percent was 23.7 for guanine, 25.2 for adenine, 20.9 for cytidylic acid, and 30.4 for uridylic acid. The base percentages for RNA-1 and RNA-2 determined separately were only different for cytidylic acid. The hyperchromic profile for the M component was broader than that for B and the melting point ( $T_m$ ) was higher (M = 55°, B = 48°). Only half of the particles were dissociated at the  $T_m$  value. Freezing dissociated most of the M component into RNA-2 and protein but had no effect on the B component. Sodium chloride protected the particles from low-temperature disruption.

The enzyme-labeled immunosorbent assay (ELISA) was a reliable and sensitive technique for detecting viruses in grapevines. Fanleaf, arabis mosaic, tomato ringspot, and tobacco ringspot viruses were identified in infected grape leaves; fanleaf and arabis mosaic viruses were distinguishable when tested by the ELISA technique but not by the agar immunodiffusion test. Tomato ringspot virus was identified in vineyards of the cultivars Chelois, Ventura, and Vincent and tobacco ringspot in vines of Pinot Chardonnay. The diseases cause significant loss of crop and are characterized by specific symptoms.

A COPI contract has been established with the Ontario Grape Growers Marketing Board so that virus-tested grapevines can be provided to the industry. The Board has contracted to establish a 6.0 ha mother block of virus-tested vines consisting of both rootstock and scion varieties.

*Reduction of copper toxicity in sweet cherry.* Premature defoliation in sweet cherry trees sprayed with Bordeaux mixture for control of bacterial canker was reduced by amending sprays with rapeseed oil. The time

of 50% leaf drop was delayed with amended sprays by 10–14 days on the cultivars Venus, Vista, and Hedelfingen. Vegetable oils are recommended for use with Bordeaux mixture to prevent possible long-term effects on growth and to limit winter injury due to premature defoliation.

*Tomato ringspot (TRSV) virus in peach.* The effect of TRSV on tree growth as judged by increases in trunk diameter of peach understocks was assessed under growth-room conditions. Although all stocks were noticeably affected, the order of increasing injury was Bailey, Harrow Blood, Elberta, Chui Tum Tao, Siberian C, Halford, Rutgers Red Leaf, and Lovell. The ELISA technique was assessed and proved capable of detecting the various strains (grape, apricot, peach) of TRSV in peach tissues. It was up to 200 times more sensitive than bioassay. The highest virus titers were found in roots, followed by leaves and shoots.

*Botrytis bunch rot of grapes.* Bunch rot of grapes caused by *Botrytis cinerea* has become especially serious in plantings of *Vitis vinifera* and in some hybrid cultivars grown in Ontario. In 1979, Pinot Chardonnay, Gamay Beaujolais, and Johannesburg Riesling were equally affected; 77% of the bunches were infected and 20% of the crop was rotten by late September. Fungicide programs employing mancozeb plus dinocap, captan, sulfur, and chlorothalonil appeared to have no suppressive effect on the disease. Cultures of *B. cinerea* resistant to benomyl were identified in five of ten vineyards, although fewer than six applications of benzimidazole fungicides had been made at each location during the past 3 yr. Iprodion may offer promise in combating this disease.

## Vegetable crops

*Effect of seeding date on the incidence of the aphid-transmitted carrot thin-leaf virus.* Younger carrots from the mid-June planting had a higher incidence of virus infection than did the older ones from the earliest planted crop. Seventy-five percent of the carrots sampled from the mid-June planting were infected whereas 53% of those taken from the planting in mid-May were affected. The roots of virus-infected carrots were slightly smaller than those of virus-free plants.

*A simple regression equation for predicting virus incidence in pepper in advance of*

*transplanting.* A temperature-dependent regression equation for the Niagara Peninsula was developed to forecast the incidence of aphid-transmitted virus diseases of peppers before transplanting. Predicted virus incidence values based on this equation were within  $\pm 5\%$  of the observed field incidence at 11 of 13 locations monitored throughout southern Ontario. The results suggest that the equation has generally broader applicability than just the region for which it was developed initially.

*Effects of interplanting peppers with other vegetable crops on virus incidence and aphid populations.* Incidence of aphid-transmitted virus diseases in peppers was increased by planting eggplant, cabbage, celery, or onion either within or on the north or south sides of experimental pepper plots planted in an east-west direction. Magnitude of the increase was dependent on the plant species used and their location relative to the pepper planting. The largest number of pepper plants was infected when either onion or eggplant was used. Aphid catches were generally reduced by interplanting with these vegetables. No correlation was apparent between total aphid populations and virus incidence in mid-September.

*Maize dwarf mosaic virus (MDMV) in sweet corn.* A virus not previously reported in Canada was found in 1978 in Quebec in sweet corn. The reaction of isolates on Johnson grass, Dekald E59+ sorghum, and wheat suggests that the virus is MDMV (strain A). Electron micrographs of negatively stained dip preparations of infected sweet corn revealed the presence of long flexuous particles. About 60% of the particles examined had a length of 700–750 nm; the average width of these particles was 12–15 nm. Ultrathin sections of infected sweet corn contained pinwheels, laminated aggregates, tubes, and some dense bands in the cells, characteristic of potyviruses of which MDMV is a member.

*Pea root rot.* The severity of pea root rot in five fields in central Ontario increased with the season. The *Fusarium solani* (Mart.) App. & Wr. f. sp. *pisi* (F.R. Jones) Snyd. & Hansen population in root tissues was related directly to disease severity. This fungus did not affect emergence of pea seedlings 10 days after seeding in infected soil, but did cause various levels of root rot 28 days after

transplanting. *Rhizoctonia solani* Kuhn reduced emergence of pea seedlings and caused root rot on transplants. Although all the *Pythium* species tested caused root rot, only *P. ultimum* Trow and *P. irregulare* Buism. reduced seedling emergence. Bacterial and fungal antagonists of the pea root rot pathogens were isolated from the soil rhizosphere.

## MECHANIZATION

### Contract research

*Peach harvester.* The prototype harvester developed in 1977 and 1978 was used to harvest peaches and apples. Machine-harvested Babygold 5 peaches were 84.5% processable whereas machine-harvested Suncling peaches were 62.7% processable. Immaturity accounted for 17.2% of the loss of Suncling but only 1.7% of the Babygold 5 peaches, suggesting that the latter variety is more suitable for machine harvesting. Other losses included those through the trunk seal, fruit left in the tree, bruised fruit, culls and rotted fruit, and preharvest drop. Prepicking the trees reduced the amount of immature fruit but increased the labor component. An economic model indicated that harvesting losses by machine cannot exceed hand-picking losses by more than 10% if machine harvesting is to be economical.

Machine-harvested Spy and Greening apples graded as follows, respectively: No. 1 peelers, 39% and 39%; No. 2 peelers, 49% and 53%; and juice apples, 12% and 8%. Fruit damage occurring during detachment, falling through the tree, and on the catching surface accounted for 88% of the damage to machine-harvested apples.

## EXPERIMENTAL FARM, SMITHFIELD, ONT.

### Vegetables

*Tomato breeding.* The cultivar Earlibright (ST-42) was released as a high-yielding fresh-market and whole-pack-processing tomato. It matures several days ahead of New Yorker and is comparable in early yields, but the internal color is superior due to the high crimson genes (og<sup>C</sup>). Earlibright's crack resistance and meaty interior give it better shelf life than have other early varieties tested. This small cored cultivar shows resistance to blossom-end rot, yellow top, and

blotchy ripening. Total yield and maintenance of fruit quality throughout harvest are excellent.

*Direct seeding of tomatoes.* A cone seeder gave 57% higher seedling counts and 35% higher yields of direct-seeded tomatoes when compared with two types of plug-mix seeders and a gel seeder. Based on 2 yr of data with a Newcastle loam, seeds and pregerminated seedlings desiccated rapidly in the plug mixes. In both years, planting directly into soil with ungerminated seed was the most satisfactory system.

*Concentrated tomato strained products.* Firm and soft tomato varieties contain similar amounts of total solids and soluble solids. Some firm machine-harvest types have a higher content of water-insoluble solids than the less firm hand-pick tomato varieties. All three solids fractions remain at fairly constant levels throughout the season although there is some decline later on. Canning, canned storage, and additional boiling in the can caused little or no change in solids content of single-strength tomato juice.

### Fruits

*Cell wall and apple firmness.* Selective extraction of apple cortex tissue followed by silver proteinate staining of the neutral polysaccharides gave good resolution of the cell wall structure. Fruit softening and development of a mealy texture were accompanied by wall separation, enlargement of the intercellular spaces, and consequent rounding of cells. Staining pattern and intensity were related to the fruit firmness and storage characteristics of the variety. Changes in ultrastructure, such as low neutral polysaccharide levels in the corners of cells, were associated with early wall separation and fruit softening.

*Calcium chloride dips extend shelf life of McIntosh.* McIntosh apples dipped in CaCl<sub>2</sub> for 1 min prior to cold or controlled-atmosphere storage for 5 mo were examined after 1, 10, and 16 days at room temperature. Immediately after removal from storage the dip had minimal effect on firmness. As the fruit remained at room temperature the untreated apples softened much more rapidly than did those that were dipped. After 16 days, apples dipped in 4% CaCl<sub>2</sub> were 0.6 kg firmer than the control fruit.

*Thinning Red Melba and McIntosh with ethephon.* Ethephon at either 150 or 300 ppm

was applied to mature trees 25 or 35 days after petal fall. The early application to Red Melba reduced fruit set and increased fruit size, with more response at the higher concentration. The later spray required a higher concentration to thin the trees but there was no increase in fruit size.

Ethephon applied to McIntosh was more effective when applied early; the response was related to concentration. The later spray did not affect fruit size.

*New apple cultivars.* Three selections resistant to apple scab were named. Britegold (0-652) is a smooth, pale yellow, medium-sized fruit which occasionally has some slight blush of light red. The flesh is low in acid, tending toward being sweet. Harvested about 1 October, the fruit can be stored for 2½ to 3 mo at 0°C. No russeting or prominent lenticel spots have been observed.

Murray (0-628) is harvested the last week of August. It is an attractive red apple. The 75–80% overcolor of lightly striped medium to dark lively red covers a greenish yellow ground color. The fruit has a juicy white flesh with a fine texture, a moderate acidity, and a pleasant flavor. Storage life for this early apple is 4–6 wk at 0°C.

Trent (0-531) produces medium large fruit similar in size to McIntosh and has been equivalent in production on *M. robusta* 5 rootstock. The 85% overcolor is a medium dark lively red on a green yellow ground color. Fruit cortex is creamy with a significant greenish tinge indicative of the requirement for a longer growing season than occurs in eastern Ontario. Harvested in late October the fruit can be stored for 8 mo at 0°C. The flesh is slightly coarse, firm, and juicy, with moderate acidity and medium quality.

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# Animal Research Institute

## Ottawa, Ontario

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<sup>4</sup>Seconded to the Planning and Evaluation Directorate, Research Branch, April to May 1979.

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## INTRODUCTION

The Animal Research Institute is the main Canadian center for research on breeding and selection of dairy cattle, sheep, and poultry; it also has major research programs on the nutrition of dairy cattle, swine, sheep, beef cattle, and poultry, as well as basic research programs on animal waste utilization and management, trace minerals, ruminant physiology, and animal feed safety and nutrition. The nine research program teams are generally multidisciplinary and are comprised of scientists with a broad range of scientific expertise and background. Both applied research and the necessary basic research are carried out by these teams.

The Animal Research Institute continues to devote a large effort to studying the problems of intensively housed and managed cattle, sheep, swine, and poultry. Scientists of several disciplines—in particular genetics, nutrition, and reproductive physiology—are involved in both multidisciplinary and single-disciplinary studies to resolve the problems associated with intensively housed animals. As a corollary of this work, studies continue on optimizing the utilization of animal wastes by recycling them through crops for animal feeds.

In 1979 a minor reorganization of the program team structure was completed with the amalgamation of the rapeseed oil nutrition and pesticide residues programs into the animal feed safety and nutrition program. Currently members of this group are completing work on the nutritional quality of rapeseed oil and the associated work on the metabolism of saturated and unsaturated fats and oils. They are also studying the effects of naturally occurring agricultural toxicants such as mycotoxins and their effect on the performance of livestock and poultry. Two scientists continue to investigate the metabolic pathways and tissue retention of the more widely used livestock pesticides to ensure they are not harmful or retained in animal products.

Significant progress was made in 1979 in a number of research areas. The key advances were the following: the vitamin D requirement for ruminants fed forage in northern latitudes was established; the toxic effects on pigs of the corn mycotoxin zearalenone were shown; and the highly significant and important effect of subclinical lymphoid leukosis on poultry production was defined. An external review of the long-term national cooperative dairy cattle breeding project examined progress to date and recommended continuation of this major research project. Further details on these and other research areas are contained in this annual report.

In September, the Poultry Science Association awarded the prestigious American Feed Manufacturers' Association Award for 1979 to Dr. Ian Sibbald for his outstanding research in poultry nutrition. Dr. Sibbald has developed a bioassay technique for routine evaluation of the energy content of poultry feeds; the technique is a significant improvement over conventional procedures and it is being extended to assess the availability of amino acids in feedingstuffs.

Institute staff are becoming increasingly involved as scientific authorities for various federal contract research programs and projects with private companies and universities. Contract research is playing an important role, together with government in-house research, in solving problems facing Canadian agriculture. The Institute is developing contract research programs in the areas of reproductive physiology, swine nutrition, ruminant nutrition, and livestock feed from waste. Some of this work is reported on in the following pages.

The sophisticated feed mill at the Greenbelt Farm was brought into full operation this past year and it extends the research capability of the Institute to a significant degree, making it possible to study some aspects of animal production and feeding not previously feasible. Construction of the new isolation barn was also completed in the past year. It will further protect the health status of the Animal Research Institute herds and facilitate the introduction of animals after appropriate quarantine periods.

This annual report records highlights of the Institute's accomplishments in the nine program areas in 1979. More detailed information can be obtained from the publications listed at the end of the report. Reprints of the publications and copies of this report are available on request from the Animal Research Institute, Headquarters Building, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

R. S. Gowe  
Director

## ANIMAL WASTE UTILIZATION PROGRAM

### Tile drainage water from manured and fertilized fields

Dairy cattle liquid manure (DCLM) was applied at an annual rate of about 250 kg of nitrogen per hectare, each spring and fall for a 4 yr period, on three corn fields (4.1, 5.6, and 27.5 ha). About 55–75% nitrogen (N), 75–85% phosphorus (P), and 50–75% potassium (K) applied in the manure each year could not be accounted for by crop uptake and tile drainage. The latter removed less than about 10% N, 0.3% P, and 2.0% K of the applied amounts. Continued manure applications at moderate rates did not appear to have any great effect on the physical and chemical quality of the tile drainage water except for nitrate nitrogen ( $\text{NO}_3\text{-N}$ ). Mean annual concentrations of  $\text{NO}_3\text{-N}$  in the three manured fields and one chemically fertilized field were related to nitrogen application history.

### Surface drainage water from an intensively cropped area

Surface water quality and nutrient and pollutant transport to it were studied for a 4 yr period in a 694 ha, largely tile-drained land area, which was cropped with silage and grain corn, legumes, and grasses and into which large quantities of manure were annually incorporated under a controlled management program. Water quality was generally better than acceptable Canadian levels for public water supplies. The range of annual unit area contributions to drainage water expressed in kilograms per hectare per year were: total solids 430–1050; suspended solids 50–400; total N 11–24;  $\text{NO}_3\text{-N}$  8–19; total P 0.4–0.8; and K 8–16.

### Pipeline transportation of liquid manure

Pipeline pressure drops and pump characteristics were determined for a system to pump relatively thick DCLM, containing 5–10% total solids, from an animal barn to a distant field storage site through a 914 m long, 100 mm diameter polyethylene pipe. One specific pump was identified which was

capable of pumping the manure slurry at 16–22 L/s through the above system. The observed pipeline friction losses were substantially greater than those reported in the literature for similar manure types and pipe size; however, the reported test systems usually consisted of recirculation of the manure through the pump and the pipe test-section.

### Surface water quality and time and rate of manure application

In a cooperative project with Engineering and Statistical Research Institute and Land Resource Research Institute, plot studies were conducted on the relative effects of time and rate of application of DCLM on water quality in corn fields. Over a 5 yr period, winter-applied manure resulted in substantially higher concentrations of N, P, and K in spring surface runoff, compared to spring, fall, and spring/fall applications.

## TRACE MINERAL AND BEEF CATTLE NUTRITION PROGRAM

### Beef production systems in the Northern Claybelt area

In studies at the Kapuskasing Experimental Farm, three groups of cows calving in March and April were fed formic acid-treated grass silage during the winter. In the spring, one group remained in the barn and was fed silage ad libitum. The other two groups were pastured in fields fertilized with N at 80 or 160 kg/ha. The cows were stocked at a rate of 1.5 cows per hectare on a 20 yr old permanent pasture containing red fescue, timothy, and Canada bluegrass. During the grazing season, 24 May to 1 October, calves gained 1.08, 1.16, and 1.20 kg/day when their dams were kept inside or grazed on pastures fertilized with N at 80 or 160 kg/ha, respectively. The weight changes of the cows were similar for all treatments. These results reinforce previous data, indicating that at this stocking rate there is no benefit from increasing pasture N fertilization above 80 kg/ha.

Direct-cut, formic acid-treated grass silage was fed ad libitum during the winter for 218 days to 36 Shorthorn  $\times$  Hereford steers. The



silage was cut on 27 June, 19 July, or 16 August. The steers fed these silages gained 0.71, 0.42, and 0.35 kg/day, respectively, and had feed conversion ratios of 9.0, 14.3, and 17.3 kg dry matter per kilogram gained. The results show the impact of date of cutting of grass upon the quality of the resulting silage. However, weight gains observed last year with silages made on 14 June and 10 July were superior to those observed this year with the silage cut on 27 June. Clearly, year-to-year variation in silage quality can be great and the date of cutting, while important, is not a completely reliable indicator of the nutritional value of silage.

Previously, it has been observed that yearling heifers lose weight when they are first put on pasture. This weight loss was further examined by putting three groups of 14 heifers out to pasture, on 22 May, 5 June, and 19 June. The heifers initially weighed an average of 320 kg and during the 1st wk on pasture they lost 11, 9, and 7% of their body weight. It took 5 wk or more to return to their original weight. The degree of weight loss was related to the maturity of the grass at the time the heifers were first put on pasture. The cause of the weight loss is not known but a reduction in fecal dry matter was observed, which could be an indication of a digestive upset, possibly caused by the sudden change in diet.

### **Manganese nutrition and metabolism**

Studies showed that feeding pregnant ewes a manganese (Mn) deficient diet may result in leg-joint abnormalities in their newborn lambs. Manganese affects the mucopolysaccharide and protein composition of the epiphyseal plate of the joint, and Mn supplementation in diets of dams is necessary to obtain normal development of bones and subsequent optimal growth in the offspring. However, oversupplementation of diets with Mn (>300 ppm) may result in decreased growth and feed efficiency. Feeding increased levels of Mn to sheep has shown a proportional increase of Mn in the rumen bacteria and protozoa. With bacteria the increase was higher in the cell walls than in the cytoplasm. It is evident that dietary Mn oversupplementation in the ruminant results in decreased biological availability and absorption of Mn due to higher incorporation into bacterial cell walls which are poorly digested. Only 21% of the total Mn content in the rumen of sheep

was found in the soluble fraction regardless of dietary concentration of Mn.

### **Concentration of liposoluble vitamins in the blood of cattle**

Blood profiles for 25-hydroxyvitamin D (25-OHD), a metabolite of vitamin D, and for vitamins A and E have been established in beef cattle winter-fed oat silage, grass silage, or hay at the Kapuskasing Experimental Farm. During the winter, plasma 25-OHD decreased in all groups, with the decrease much greater in the heifers fed oat silage than in those fed grass silage or hay. At the end of winter, plasma 25-OHD in the oat silage-fed heifers approached levels that were suggestive of vitamin D deficiency. A single intramuscular injection of vitamin D<sub>3</sub> increased plasma 25-OHD in all groups, with the heifers on grass silage being more responsive to the injection than those on oat silage or hay. Weight gains were improved by the injection of vitamin D<sub>3</sub> in heifers on oat silage.

### **Cement kiln dust supplements for ruminant diets**

In experiments in the United States, improvements in ruminant weight gain and feed efficiency were obtained by dietary supplementation with cement kiln dust from a plant in Georgia. To assess effects of cement kiln dusts of Canadian origin, material obtained from two separate sources was fed to growing lambs. No beneficial effects were obtained from the two Canadian cement kiln dust supplements.

## **DAIRY CATTLE BREEDING AND PRODUCTION PROGRAM**

### **National cooperative dairy cattle breeding project**

Results from the pureline foundation phase for the H line are based on the progeny of Research Branch, Canadian, and U.S. Holstein bulls mated to Research Branch Holstein cows. The A line females of this phase are progeny of Canadian, U.S., Finnish, and Research Branch Ayrshire bulls, Brown Swiss bulls, and Norwegian Red bulls mated to Research Branch Ayrshire cows. The oldest animals in this phase have completed five lactations while the youngest are completing their third. Detailed analyses comparing the different sire groups in each line have been

completed for many traits. Results for heifer growth and reproduction and first-lactation milk, butterfat, and protein yields are summarized in this annual report.

Though the H line progeny of the Canadian Holstein bulls were larger at birth than the U.S. or Research Branch progeny (41.2 kg versus 40.9 and 39.8 kg), their weight at 574 days of age was slightly smaller (436 kg versus 447 and 443 kg, respectively). The outside breeds used in the foundation A line matings were chosen to broaden the genetic base of the line and to improve size and milk yield. Brown Swiss progeny were the largest at birth (36.3 kg) and had superior growth through first freshening. Growth was similar for all outside groups through 238 days of age. From 238 to 574 days of age the Brown Swiss and Norwegian Red progeny grew at a more rapid rate and were the largest at first calving. Average first-calving weights were 437, 426, 402, 415, 408, and 413 kg for the Brown Swiss, Norwegian Red, Research Branch, Canadian, U.S., and Finnish Ayrshire progeny, respectively.

All project heifers are bred at the first heat occurring after 350 days of age. The average ages at first heat for the Canadian, U.S., and Research Branch Holsteins were 333, 322, and 342 days of age, respectively. However, the three groups did not differ in age at first calving or services per conception. First heat occurred from 18 to 45 days later in the A line groups except the Norwegian Red, which had an average age at first heat of 336 days. The average age at calving for the A line groups ranged from 692 to 699 days of age with services per conception ranging from 1.7 to 2.1.

As expected, progeny of both the Canadian and U.S. Holstein proven bulls, selected on milk proof, had higher milk, fat, and protein yields than the daughters of the untested young Research Branch bulls which came from a previous selection project for total solids. The most significant result of this phase of the project comes from the first-lactation milk, fat, and protein yields of the various A line groups. While there were no differences among the Ayrshire groups, the Norwegian Red progeny produced about 600, 20, and 15 kg more milk, fat, and protein, respectively, than any of the Ayrshire groups and about 300 kg more milk than the Brown Swiss progeny.

### **Field test of Finnish Ayrshires**

Proven Finnish and Canadian Ayrshire bulls were compared in Canadian Ayrshire herds. Macdonald College of McGill University, the University of Guelph, and the Animal Research Institute, in cooperation with breeders and artificial breeding units in Ontario and Quebec, made the test matings. A total of 130 daughters of the three Canadian bulls tested and 87 daughters of the four Finnish bulls tested completed first-lactation records. Daughters of Canadian bulls produced 173 kg more milk and 1.6 kg more milk fat than daughters of Finnish bulls. The breed class average (BCA) values, which adjust for age at calving, showed a 4 BCA superiority of daughters of Canadian bulls for milk, but the difference for milk fat was negligible.

### **Bull progeny tests in France**

Studies are continuing with Research Branch Holstein bulls which are being compared to several groups of Black and White bulls in use in France for various traits in both male and female progeny. About 15 young males from the eight Research Branch bulls and an equal number from the other Black and White bulls currently in use were slaughtered for detailed carcass measurements. Measurements included liveweight, warm and cold carcass weight, carcass length, dressing percentage, sirloin and rump thickness, percentage of lean, fat and bone at the 11th rib, weight of internal organs, and the carcass grade as per the European Economic Community standards. These data along with growth and feed efficiency data are currently being analyzed by the French scientists. Recording of milk yield on the daughters is proceeding as planned with at least 50 daughters per bull.

### **Breeding studies using record of performance data**

Records-in-progress from Ayrshire, Guernsey, Holstein, and Jersey first-lactation cows were used to predict 305-day records using U.S. Department of Agriculture (USDA) extension factors. The differences between the actual and projected yields were positive indicating that USDA extension factors were underestimating both milk and fat yields for the four breeds. For the Holstein breed, phenotypic correlations between the projected records-in-progress and actual 305-day milk yields increased from 0.44 for up to 29 days in

milk to 0.98 for 270–304 days in milk. Similar correlations were also observed for the other breeds. The results of this study suggest that the USDA extension factors, when used on the Canadian data, underestimate 305-day milk and fat yields from shorter partial records for the four dairy breeds studied. More accurate extension factors are required.

### **Pilot genetic studies with mice**

Genetic principles fundamental to the current dairy cattle crossbreeding experiments are under investigation using mice.

Eight lines from two random-bred populations of mice, different in milk production or adult weight, or both, were used to evaluate the growth, feed efficiency, and lifetime performance of the eight lines and 16 of their  $F_1$  crosses. Growth and feed efficiency were examined over the period from weaning (day 21) to maturity (day 63). Lifetime performance was measured as the total body weight of litters raised to weaning by a female during the 200 days after mating (day 63), with each litter being standardized to nine young at birth. Lines and crosses did not differ in growth measured as day 63 body weight (32.6 g versus 33.0 g, respectively) or feed efficiency (8.2% versus 8.3%, respectively, between days 21 and 63) but they differed in the lifetime performance (589 g versus 649 g). Heterosis in the lifetime performance for the various crosses ranged from -45 to +178 g. Line crosses between populations showed a larger heterosis than line crosses within populations. Crosses from lines selected for increased milk production or adult weight or both had a smaller heterosis and lifetime performance than crosses from the unselected control lines. The latter crosses showed a persistent production throughout lifetime. Data on growth and feed efficiency were further examined to compare genetic parameter estimates from three different genetic analyses (models). Correlation coefficients of line ranking ranged from 0.87 to 0.97 for breeding values and maternal genetic effects. The methods yielded similar estimates of the genetic parameters required to predict crossbred performance.

### **Monitoring the reproductive status of the postpartum cow**

Rectal palpation was used to monitor the reproductive status of the postpartum dairy cow by examination of all nonpregnant cows in the herd every 28 days. To December 1979,

examinations have been carried out on 524 cows. Preliminary analyses indicate that only 52% of the cows have been observed in estrus between parturition and 56 days postpartum, and conceptions to first service, as diagnosed by rectal palpation, average about 50%. Cystic ovarian degeneration or cystic ovaries occurred in 19% of the older cows and 6% of the first-calf heifers with no differences observed among the H and A lines or cross-breeds. Most cysts appear to regress spontaneously.

### **Maternal recognition of pregnancy and hormone synthesis by the conceptus**

Intact cells of the pregnant sheep uterus were found to synthesize three major prostaglandins;  $E_2$ ,  $F_{2\alpha}$ , and prostacyclin, which are not produced by the nonpregnant uterus on the corresponding days of the estrous cycle. The same substances are produced by the embryo. Prostaglandin  $E_2$  and prostacyclin stimulate steroid formation. It is thought that if the embryo stimulates prostaglandin formation by the uterus, then it may both directly and indirectly affect the ovary ensuring the maintenance of pregnancy.

## **DAIRY CATTLE NUTRITION PROGRAM**

### **Use of urea in dairy cattle rations**

Urea added to corn silage and fed with concentrate in a complete diet containing 12–13% crude protein (CP) supported milk production at a level comparable to a diet supplemented with soybean meal. An experiment was designed to establish if urea can be used by the cow when fed in corn silage in a complete diet containing 15% CP. All diets were supplemented with soybean meal to provide 12–13% CP. Two diets were increased from 12% to 15% CP by the addition of either soybean meal or fish meal. A third diet was increased to 15% CP with urea-treated corn silage, and the fourth diet at 12–13% CP was the control. All diets were fed free choice. Preliminary results show that rumen ammonia concentrations are higher for cows fed 15% CP than for those fed 12–13% CP. A higher concentration of rumen ammonia was observed in cows fed the 15% CP diet supplemented with soybean meal as compared to that containing fish meal. Rumen microbial numbers were higher in rumen fluid from

cows consuming soybean meal diets than those consuming diets containing fish meal. Production parameters in these different diets are being measured.

#### **All-silage forage rations for growing heifers and lactating dairy cows**

One hundred heifers were fed a forage ration composed of 40% corn silage and 60% (dry matter basis) formic acid-treated direct-cut alfalfa silage from 56 to 574 days of age. A control group received 40% corn silage, 20% wilted silage, and 40% hay. Both groups received equal quantities of a calf starter to 182 days and a calf grower from 183 to 350 days of age. Forage consumption was similar for the two rations. Average weight gains of 0.78 kg/day were observed for the all-silage forage rations in comparison with 0.75 kg/day for the control ration; this difference was significant ( $P < 0.05$ ). A corresponding difference in body development was observed, but no differences were noted in fertility, health, or reproduction. It was concluded that heifers can be raised successfully on a forage mixture consisting of corn silage and formic acid-treated alfalfa silage, without the use of hay.

In a similar experiment, with a rolling average of 240 cows kept under complete confinement in four pens of a loose housing barn and fed complete diets, two groups received a ration consisting of 30% formic acid-treated direct-cut alfalfa silage, 30% corn silage, and 40% of a 12.5% crude protein grain-mineral mix (treatment 1). Another two groups were fed a mixture of 38% corn silage, 15% wilted silage, 7% hay, and 40% of a 21% crude protein concentrate (treatment 2). Dry matter intake for treatment 1 was 16.0 kg/day compared to 17.6 kg/day on treatment 2. Corresponding milk production data over 499 lactations were 5490 and 5680 kg per lactation for Holstein cows and 4360 and 4470 kg for Ayrshire cows. No difference in health, fertility, or reproduction were observed between the two treatments. It was concluded that formic acid-treated silage can supply a large proportion of the protein and energy required by lactating cows, and that hay can be eliminated from the diet. Some decrease in dry matter intake may result from feeding an all-silage ration.

#### **Rumen bacteriology**

The nucleus of a bacterial-type culture collection has been established and optimal methods for long-term storage are being determined. At present 27 bacterial strains, representing 23 bacterial species, have been obtained from the American Type Culture Collection or from other laboratories. An additional 118 strains, including 30 cellulolytic organisms, have been isolated. Simplified methods for the classification of new isolates are being developed using a combination of conventional biochemical techniques and more recently developed analytical methods such as sodium dodecylsulfate polyacrylamide gel electrophoresis and computer data processing.

Studies on the distribution and taxonomic significance of plasmids in rumen bacteria are in progress. It has been found that plasmids are commonly found in many rumen bacteria species and it appears likely that these plasmids may play an important role in determining the properties of individual bacteria.

#### **Forage evaluation**

The two-stage Tilley and Terry technique (incubation with rumen fluid followed by an acid-pepsin digestion), used to estimate dry matter digestibility (DMD) of forage in vitro, was evaluated with oven-dried corn silage as a substrate. As the quantity of substrate used per incubation was increased from 0.1 to 3 g, the percent DMD decreased in a linear fashion. Continuous shaking of tubes resulted in a more rapid attainment of maximum DMD values for a given quantity of substrate as compared to mixing the incubation contents twice daily. The disappearance of dry matter (DM) was related to the appearance of volatile fatty acids (VFA) during a 48 h incubation. With 0.1 g corn silage, 96% of the DM which disappeared could be accounted for as VFA. As the quantity of corn silage in the incubation increased, the production of VFA also increased; however, the quantity of DM which could be accounted for as VFA fell slightly. The volume of rumen fluid inoculum, as well as the number of microbes contained therein, was found to influence the extent of DMD of corn silage.

## Preruminant calf nutrition

An in vitro study was conducted on the proteolytic efficacy of 10 separate proteinases for nine milk and four nonmilk proteins commonly used in calf milk replacers. The objective was to obtain some insight into the observed differences in digestibility of various proteins in calves and an indication of which proteases might be added to replacers to improve digestibility of nonmilk proteins. Immediately after feeding, when the pH of the calf stomach contents is 6.1, pepsin had some proteolytic activity on milk proteins but not on soy, fish, or rapeseed proteins. At 5 h after feeding, when the pH is 2.0, pepsin had good hydrolytic activity on all proteins tested. The other stomach proteinase, rennet (chymosin), had only slight activity and solely on the milk proteins. Trypsin and chymotrypsin, the enzymes secreted into the small intestine of the calf, had good proteolytic activity on milk proteins and fair activity on nonmilk protein substitutes at pH 6.1 or higher. The commercial enzymes pronase and papain hydrolyzed all proteins extensively. The results suggest that it may be beneficial, when calf milk replacers contain poorly digestible nonmilk protein concentrates, to predigest the proteins with pronase or papain or add these enzymes to the diets.

## Protein degradation in the rumen

Dietary proteins are known to be extensively degraded in the rumen. However, a certain amount of dietary protein escapes this degradation and reaches the small intestine for further digestion and absorption. This protein is called bypass protein and the amount varies with different feed proteins. Currently there is growing emphasis on formulating feed with high bypass protein. Protein solubility has been equated to degradability, with the suggestion that soluble proteins are completely degraded whereas insoluble proteins are not. Feeds are formulated on the basis of protein solubility. The validity of these assumptions was investigated using rumen bacterial protease and a variety of soluble and insoluble proteins. The results show that proteins such as serum albumin and ribonuclease A are highly soluble, but they were resistant to hydrolysis; the soluble and insoluble proteins of soybean meal were hydrolyzed at almost identical rates; the soluble proteins from soybean meal, rapeseed meal, fishmeal, and casein were hydrolyzed at different rates.

In a further study, serum albumin, ribonuclease A, insoluble fishmeal, and insoluble rapeseed meal proteins were treated with mercaptoethanol in 8 M urea or oxidized with performic acid. These chemical treatments are known to specifically disrupt disulfide cross-linkages in proteins. Following these treatments, the resistant proteins became quite susceptible to hydrolysis by rumen bacterial protease even though there was no change in their solubility. It was concluded that solubility or insolubility of a protein by itself is not an indication of its susceptibility or resistance to hydrolysis by rumen protease.

## SWINE PRODUCTION PROGRAM

### Development and maintenance of minimal-disease herd for intensive research

The minimal-disease herd established in 1977 is now in the fourth generation and continues to be free from rhinitis, virus pneumonia, and internal and external parasites. The incidence of noninfectious post-weaning scours is minimal. An agreement was concluded with the Ontario Ministry of Agriculture and Food to supply 120 bred gilts from this herd to establish a new minimal-disease herd at the University of Guelph.

### Age at puberty in gilts

Gilts fed ad libitum reached puberty at a significantly ( $P < 0.05$ ) younger age than gilts restricted-fed twice daily (158 versus 172 days of age), confirming an earlier observation.

Under an Institute-supported research contract, the effect of age at puberty on carcass composition at 109 kg was investigated at the University of Alberta. Gilts that came into puberty prior to attaining slaughter weight grew more slowly ( $P < 0.001$ ) than those not attaining puberty. Within the group that did attain puberty, the fastest growing gilts attained puberty at the youngest age. There were no differences in carcass composition at 109 kg. Selection of gilts for early maturity could result in a reduction in growth rate to market weight and possibly an eventual reduction in mature body size.

### Energy protein requirements for pregnancy in the once-bred gilt

Gilts bred at first estrus were fed a standard sow ration at either 1.8 kg/day or 0.45

kg/day from day 100 of gestation. Piglets were removed at birth and the gilts slaughtered, either within 48 h of farrowing or after a 10 day refeeding period, and their carcasses were assessed as to quality and acceptability. The gilts averaged 171.3 days of age and 102.6 kg at first estrus. Those receiving 1.8 kg/day throughout gestation farrowed 8.3 live-born pigs with an average birthweight of 1.15 kg, while those restricted to 0.45 kg/day from day 100 of gestation farrowed 8.4 live-born pigs with an average birth weight of 1.17 kg. A 10 day postpartum refeeding period did not conclusively resolve the tough meat problem previously encountered. Although loin samples were tougher than those from control animals, ham samples were not.

### **Gestation feeding level and the newborn pig**

Gilts fed 1.36 kg/day from breeding to day 85 of gestation were allocated to two groups: the controls continued on 1.36 kg/day whereas the test group was restricted to 0.45 kg/day to farrowing. Feeding level from day 85 of gestation significantly ( $P < 0.001$ ) affected weight gain of the gilts with the restricted gilts losing 3.2 kg while control gilts gained 15.0 kg. Litter size was not affected; however, total weight of live-born piglets was reduced in the restricted group. Prenatal feed restriction significantly ( $P < 0.05$ ) reduced individual piglet birth weight (1.1 versus 0.9 kg), liver weight (32.9 versus 26.0 g), and skeletal muscle weight (8.9 versus 7.1 g and 2.1 versus 1.6 g for the longissimus and semitendinosus muscles, respectively) and liver and muscle glycogen concentrations (15.1 versus 13.9 g, 10.1 versus 9.4 g, and 9.9 versus 9.4 g per 100 g wet tissue for the liver and longissimus and semitendinosus muscles, respectively). Piglets born to restricted dams also had a lower ( $P < 0.05$ ) blood pH (7.31 versus 7.23) and higher ( $P < 0.01$ ) blood lactate levels (43.8 versus 71.3 mg/100 mL).

### **Nutrient requirements of the early-weaned pig**

Under an Institute-sponsored research contract, a basal semipurified diet suitable for studying the amino acid requirements of the neonatal pig was developed at the University of Guelph. This diet provided 40% of the dietary protein as skim milk powder and the remainder as purified amino acids. Using this diet the lysine requirement of the 14 day old

piglet was found to be 1.2% of the diet. Similarly, the methionine requirement was found to be 1.2% of the diet. Similarly, the methionine requirement was found to be 0.27% of the diet when cystine and choline were in adequate supply.

### **Separation and concentration of porcine gamma globulin from abattoir blood**

Studies continued to develop a continuous-flow system for the separation and concentration of porcine gamma globulin from abattoir blood to replace the currently used batch process based on ammonium sulfate precipitation. The time required for dialysis of the serum was reduced by a factor of 50 through the use of continuous-flow electro dialysis. Separation of the gamma globulin fraction from the albumin fraction using ion exchange chromatography was achieved; however, mechanical problems have been encountered in the regeneration of the resin bed. A 10 times concentration of the isolated gamma globulin was realized using continuous-flow reverse osmosis. The gamma globulins produced from abattoir blood will be used in milk replacers for artificially reared piglets.

### **Growth performance in pigs**

Boars and gilts were fed to a constant age, constant weight, or constant feed intake. Boars were more efficient in utilizing feed for growth than were gilts. Lean content in the carcass was also higher in boars. The results indicate that with relatively less feed, boars can attain slaughter weight sooner than gilts.

### **Preparation of pig carcasses for chemical analysis**

Porcine carcass material is highly heterogeneous, yet chemical analysis requires a fully representative homogeneous sample of workable size. A study was undertaken to determine the number of grindings required to achieve a homogeneous sample. A frozen side was cut into three pieces and passed through a 37 kW worm-fed meat grinder. As the ground tissue was expelled, three 200 g samples were taken. The grinder was dismantled and the material left in it was recovered and added to the ground material; the resulting mass was reground. This procedure was repeated until the carcass material had been passed through the grinder 10 times. The resulting samples were analyzed to determine dry matter, nitrogen, ether extract, and ash. The degree of

variation within a trio of samples obtained from each successive grinding was considered to be a reflection of its degree of homogeneity. The results indicated that a representative preparation, sufficiently homogeneous to allow precise analysis of samples, was achieved after five grindings.

## **POULTRY BREEDING PROGRAM**

### **Selection studies in egg production chickens**

Six selected strains have been under selection for high egg production and other economically important traits for up to 28 generations. For the hatch years 1971–1977, the selected strains had an average genetic gain of 17 eggs compared with unselected control strains maintained in parallel. For this period the strains selected on part-record egg production rate had a genetic gain of three eggs greater than the strains selected on part-record hen-housed egg production. In the selected and control strains of the 1978 hatch population, individual feed consumption was measured during a 4 wk period when all strains were producing at a high rate. After correction for initial body weight and weight gain, the control strains consumed 0.8 g feed per gram of egg laid more than the selected strains, and the strains selected on part-record hen-day rate consumed 0.13 g feed per gram of egg laid less than the strains selected on part-record hen-housed production.

The six selected strains and two of the control strains along with all 30 possible reciprocal crosses of the selected strains were evaluated in a 2 yr egg production test. In the 2nd yr, egg production was measured following a forced molt. In individual laying cages, the average hen-housed egg production from 546 to 909 days of age was 144, 166, and 189 eggs for the control strains, selected strains, and strain crosses, respectively, down from the equivalent 1st yr (134 to 497 days of age) values of 204, 253, and 269 eggs. In group cages with three birds per cage, the corresponding 2nd yr performances were 155, 168, and 184 eggs compared with 1st yr production of 198, 239, and 257 eggs. In the 2nd yr the effect of higher density housing was not as great as in the 1st yr. The egg production differences between the control and selected strains (49 and 41 eggs 1st yr and 22 and 13 eggs 2nd yr in individual and group cages, respectively) represent the average genetic gain from selection. The differences between

the strain crosses and the selected strain (16 and 18 eggs 1st yr and 23 and 16 eggs 2nd yr in the two environments) represent the average heterosis. In the 2nd yr of egg production especially for group housing, the average genetic gains were lower than those achieved in the 1st yr of production, but average heterotic effects in the 2nd yr were equal to or greater than those of the 1st yr.

In a cooperative study with the Animal Diseases Research Institute (Ottawa), results were further analyzed from a preliminary test that compared the above strains with strains derived from them and selected for resistance to Marek's disease in addition to the above traits. The performance levels in the test were similar to those given above. The resistance-selected strains showed improved viability not only when tested without Marek's disease vaccination but also when exposed to disease after vaccination. Heterosis was larger in the resistance-selected strains whose development involved inbreeding. The size of heterotic effects generally increased with increased disease exposure.

### **Genetics of poultry meat production**

Research on genetic aspects of poultry meat production concentrated on the development of techniques for reduction of obesity in the modern broiler chicken and for improvement of feed conversion.

Differences between modern commercial broiler chickens and broilers of 20 yr ago in growth rate and abdominal fatness, measured in an earlier test, have been examined in greater detail. Progeny of the Ottawa Meat Control strain represented broilers of 20 yr ago. This strain was synthesized from four broiler strains in 1958 and has been maintained by random mating without artificial selection since. Carcasses of modern broilers, slaughtered at 47 days of age, not only weighed more, 1552 versus 676 g, but also contained more abdominal fat, 37.6 versus 9.8 g. On the average, modern broilers were proportionately fatter with 2.4 versus 1.4% abdominal fat in the dressed carcass. The genetic improvement of growth rate during the past 20 yr was associated with increased carcass fatness. Variation in fatness both within and between strains indicated that carcass leanness can be improved genetically while maintaining or improving growth rate. Intrastrain examination of proportional fatness values reveals that fewer modern broilers

are as lean as broilers of 20 yr ago; however, there are few modern broilers fatter than the fattest broilers of 20 yr ago. Broilers appear to have the same genetic limits for proportional abdominal fat as their counterparts of 20 yr ago. Similar absolute amounts of abdominal fat were obtained from male and female broilers. Although males had a greater dressed carcass weight than females, 1220 versus 1048 g, males had a lower proportion of abdominal fat than females (1.8 versus 2.1%, respectively). It should be noted that the above comparisons were based on growing all birds to the age at which only modern broilers reach the desired slaughter weight. These comparisons may not reflect the body composition of broilers of 20 yr ago slaughtered later in life at a similar weight.

Prediction of abdominal fat content of the live broiler has been attempted. Abdominal and collar skin pinch scores for live birds proved to be of little predictive value when used alone or in conjunction with other traits.

Prediction equations including live body weight and length and circumference of the shank exhibited greater potential accuracy and these traits accounted for 29–55% of the variation in abdominal fat weight for specific sex and strain groups of broilers. Hence, more testing is required to see whether reliable live predictors of abdominal fat weight can be found.

“Sire type” and “dam type” genetic base populations for further selection studies are being synthesized from 16 primary broiler breeder lines obtained from commercial breeding companies. The lines assembled for this purpose were surveyed to assess the genetic variation available to the industry for further improvement of broilers. Preliminary results indicate substantial amounts of variation in male fertility and semen freezability, susceptibility to green muscle disease, incidence of shedding of lymphoid leukosis virus into eggs, as well as in production traits.

### **Disease resistance genetics**

Lymphoid leukosis is a viral disease of chickens transmitted through eggs, as well as horizontally from chicken to chicken. Mortality from the disease is generally low. Effects of subclinical lymphoid leukosis were investigated in cooperation with the Animal Diseases Research Institute (Ottawa) over 2 yr in nine strains of Leghorns. The hens shedding the virus into eggs were found to have a

higher mortality from causes other than lymphoid leukosis, to mature sexually later, to lay 25–30 eggs less per hen housed, and to have approximately 1.5 g lower egg weight and a lower egg specific gravity indicating thinner shells and potentially higher egg breakage. Fertility of such shedder hens was reduced by 2.5% and hatchability by 12.5%. Thus, eradication of the disease from poultry flocks would be expected to result in improvements in egg production. It was also found that the lower production of shedder hens results in their elimination in the process of genetic selection and that this results in a lower frequency of shedders in selected than in control strains.

In an effort to develop a technique for eradication of lymphoid leukosis from poultry flocks, the role of the male in spreading the disease was examined. Hens inseminated with semen containing the lymphoid leukosis virus became infected but did not shed the virus into eggs. Thus the male does not seem to contribute to vertical transmission of the disease.

Green muscle disease (DMS) appears to occur in older birds from a breakdown of the body's regulatory mechanisms that results in the wasting away of parts of the deep pectoral muscle. It was first observed in turkeys approximately 10 yr ago and has now been confirmed in meat-type chickens. Over a period of weeks during the course of the disease, affected muscle shows a greenish lesion that downgrades the quality of the carcass and results in an economic loss at slaughter. A survey of chicken broiler strains indicated a significant incidence of DMS and a high susceptibility to this disease in some of these strains. Because of this, the main emphasis of Institute experimental work was shifted from turkeys to chickens. Methods of inducing DMS are being evaluated and these methods, in combination with a blood enzyme test developed at the Institute will assist in the establishment of a practical field test to assess bird susceptibility to DMS.

### **Eggshell quality**

Eggshell breakage remains one of the most economically damaging problems of the poultry industry. Work on genetic aspects of eggshell quality continued in close cooperation with the Institute's poultry nutrition program. Studies were initiated to determine if estrogen and calcium levels in hen plasma



were related to shell quality. It was found that levels of estrone and estradiol were positively correlated with total calcium at 5.75 h after oviposition. In addition to the small and large plasma peaks of these hormones, which occur 5.75 and 22 h after oviposition, respectively, small and large peaks of sulfated conjugates of these hormones also occur at these times.

Understanding the genetic correlation between responsiveness to estradiol benzoate and egg shell quality may be a useful tool in practical poultry breeding. After injecting roosters with estradiol benzoate it was found that increased plasma calcium levels 4 days later were not correlated with eggshell quality, as measured by specific gravity of daughters at 450 days of age.

## **POULTRY NUTRITION PROGRAM**

### **Laying hens**

Feed intake, shell weight, egg specific gravity, percent shell, shell thickness, nondestructive deformation, and compression fracture force were measured over 21 consecutive days for two strains of force-molted hens. There was a significant difference among days but not between strains for these variables.

A phase-feeding regimen, in which dietary protein level was reduced from 15.4 to 14.8% at 272 days of age and further from 14.8 to 13.9% at 364 days, permitted laying hens to be fed lower-cost rations with no apparent decrease in percent hen-day egg production or egg weight.

### **Meat-type birds**

Propionic and lauric acids were the most effective of seven nonesterified short and medium chain fatty acids in decreasing feed intake when intravenously administered to broiler chicks. Inclusion of hydrolyzed coconut oil, a crude source of lauric acid, at 5% of a starter diet decreased feed intake by 13%. This permitted body weight control of replacement chicks during the brooding period when regulation of body weight is difficult.

Egg size was increased when the daily feed allowance for breeder hens was given in three portions per day and by feeding high- and low-protein components of the feed in the morning and evening, respectively. This management procedure increased the feed efficiency for the production of broiler hatching eggs.

Compared to broiler chicks reared under continuous light, birds grown under intermittent light (cycles of 1 h light and 3 h dark) utilized feed more efficiently and had less abdominal fat at 7 or 8 wk of age. Since carcass weights were similar for both groups of birds, this is a practical method for decreasing abdominal fat in broiler chicks.

### **Eggshell strength**

Direct evidence was obtained, by electron microscopic techniques, which showed eggshells break during the puncture test because of tensile failure.

Small decreases occurred in the compression fracture and impact fracture strength of eggs stored at 10°C for 15 days. Egg specific gravity, as measured by Archimedes' principle, decreased significantly due to decreases in egg weight.

The sequence in which nondestructive measurements were done influenced the compression fracture and impact fracture strength of eggs. For example, compression fracture strength was higher when nondestructive deformation was measured after rather than before specific gravity.

Shell breaking strength, measured by compression fracture, was significantly lower for eggs at 3 min than at 3 h after oviposition.

### **Bioavailability of phosphorus**

An assay was developed from the true metabolizable energy (TME) bioassay to measure phosphorus availability of feedingstuffs. The availability of phosphorus among seven feedingstuffs ranged from 16% for a laying hen diet to 42% for soybean meal. High variability among adult cockerels within feedingstuffs was observed.

### **Measurement of metabolizable energy and amino acid availability**

More precise TME estimates of dehydrated alfalfa were obtained when force-fed cockerels were used as their own negative control because metabolic plus endogenous energy losses were largely characteristic of the bird. Although the mean value for metabolic plus endogenous energy was lower for a group than the value for individual birds composing that group, the decrease in precision of the TME estimate was offset by a reduction in the time needed and hence the cost of the assay.

Composition of the basal diet influenced the TME values of supplementary tallow, particularly when the level of supplementation was low. Higher TME values were obtained by supplementing a corn than a wheat diet with tallow. However, it was not possible to identify the active factor by substituting wheat with fractions of corn, in amounts similar to those in the corn diet.

The rate and duration of residue output from wheat, fish meal, dehydrated alfalfa, and oats by adult cockerels was found to be a function of the input of the feedingstuff being tested. Oat residues were observed in the excreta within 2 h and continued to be voided up to 52 h after force-feeding.

Heat treatment of oil-extracted soybean flakes had no effect on clearance time or on the quantity of excreta voided 24 and 50 h after force-feeding. Mild heat treatment at low pressures (129 kPa at 107°C for 10–30 min) increased the TME values and availability of alanine, isoleucine, leucine, phenylalanine, proline, serine, tyrosine, and valine but severe heating caused a reduction in TME values and arginine, methionine, and lysine availability.

Supplementing ground corn in a laying hen diet with cellulose had no effect on amino acid excretion or availability, or on the TME values. Neither sand nor cellulose influenced the excretion of metabolic plus endogenous energy.

The rate of clearance and TME value were not affected when dehydrated alfalfa was supplemented with salt.

## **SHEEP PRODUCTION PROGRAM**

### **Development and assessment of new strains for an intensive sheep production system**

In the intensive sheep production system under development, the 1600 ewes are split into two equal flocks. Each flock is bred on an 8 mo cycle with one or the other of the two flocks bred each January, May, and September. Since January 1979, studies on light control have been completed and the entire flock has been maintained on a regimen of 18:6 h and 10:14 h light:dark, alternating at 4 mo intervals, which has been shown to be effective to induce cycling. For the three lambing periods of February, June, and October 1979, overall ewe productivity increased by 300 lambs (11%) compared to productivity in 1978 which in turn was up

19% over 1977 data. Lamb mortality was abnormally high in the June lambing period. The overall incidence of stillborns and early postnatal deaths has increased from about 5% to 10%. Average lamb losses in the sire strain are as high as, or higher than, in the two dam strains, indicating litter size per se is not a major factor. Management, particularly labor availability, is probably a key factor. Preliminary evaluation of ultrasonic instruments for pregnancy diagnosis indicates that they are sufficiently accurate to be a useful management tool.

### **Intensive rearing of lambs**

Rates of gain were reduced and mortality increased for lambs fed milk replacers (MR) in which 20% or 40% of the milk protein was replaced by a soluble fish protein concentrate compared with lambs fed MR containing all milk protein. The reduced performance was only partially overcome during the solid-diet feeding phase. However, there were indications that the reduced performance may have been at least partially due to the sugar level in the experimental diets rather than the soluble fish protein concentrate.

### **Evaluation of carcass merit**

A study to evaluate ways of predicting sheep carcass merit by means of live animal measurements compared three ultrasonic instruments (Krautkrämer USM No. 2, Scanoprobe, and Scanogram), which were used to measure backfat thickness as an indirect predictor of the lean content of the carcass. The study showed that kilograms of lean were more accurately predicted than the percentage of lean. Fat thickness contributed to the prediction of lean but its contribution was greatly reduced when body weight at scanning was incorporated into the prediction. Measurements made with the Krautkrämer USM No. 2 provided better predictions of lean carcass content than those made with the other two instruments.

### **Reproductive physiology**

*Control of estrous cycle and ovulation.* It has been established that estrus and ovulation in ewes can be effectively synchronized after a 12 day treatment with a progestagen-impregnated ear implant when the treatment is applied in the middle or at the end of the estrous cycle. If the treatment is applied at the beginning of the cycle, estrus is not

synchronized in a high proportion of the treated ewes.

Studies on factors influencing the ovulation process continued using prepubertal gilts treated with hormones to induce ovulation as an experimental model. Results showed that the follicular fluid levels of estrogen, androgen, and progesterone undergo a precise sequence of changes during preovulatory follicle growth and development. These changes are indicative of the steroid secretory activity of the developing follicle and are closely related to, and influenced by, exposure of the follicle to gonadotrophic hormones.

*Artificial insemination.* Techniques have been developed which result in lambing rates of 65–75% following a single insemination. This is comparable to those previously achieved with either two inseminations or natural mating at the synchronized estrus. It was established that a threshold level of 225 million sperm per insemination is required to achieve these fertility rates and is dependent upon sperm number and not concentration of seminal plasma components. New methods were developed which now allow fresh semen to be stored for at least 24 h without adversely affecting fertility.

Studies have demonstrated a large variability among rams in the ability of their semen to retain fertilizing capacity following freezing and thawing. Good fertility has been achieved with frozen and thawed semen from some rams, but overall fertility is about half that obtained with fresh semen. Freezability of semen improves during decreasing day length. Two new semen extenders have been developed, based on evaluation of the cryoprotection provided by several high molecular weight compounds, which have resulted in significant improvement in sperm survival following freezing and thawing. During the freezing process it has been found that medium cooling rates of 15, 20, or 25°C/min result in better sperm survival than slow cooling rates of 0.5, 1, or 2°C/min.

Inadequate or impaired cervical transport of sperm has been suggested as a factor in the lower conception rates resulting from artificial insemination with frozen and thawed semen. Isolated tissue preparations of the guinea pig and ewe cervix have been developed for screening potentially useful pharmacological agents which might influence cervical transport of sperm. Autonomic, drug-induced,

cervical contractions and rhythmic spontaneous contractions have been demonstrated.

## ANIMAL FEED SAFETY AND NUTRITION PROGRAM

### Mycotoxins

Research with mycotoxins has centered on zearalenone (Z), a metabolite of *Fusarium* mold found commonly in Ontario and Quebec. A rapid screening method for analysis of Z and eight other mycotoxins using thin layer chromatography has been developed and used to analyze suspect corn and feed samples. In a cooperative project with the Biosystematics Research Institute in which field-overwintered corn was analyzed simultaneously for mycotoxin residues and fungi present, 19 fungi were identified and trace amounts of Z and another mycotoxin, aflatoxin, were detected.

Two analytical methods were developed to specifically analyze for Z and possible metabolites. With a gas chromatographic method, free Z as low as 100 ng/mL was detected in serum. Determination of Z and  $\alpha$ - and  $\beta$ -zearalenol in the 0.5 ng/mL range is now possible using a high pressure liquid chromatographic-fluorescence detection method.

Animal studies carried out on gilts have shown low levels of free Z in serum after administering a single oral dose of crystalline Z. Analysis of urine samples indicated that  $\alpha$ - and  $\beta$ -zearalenol are metabolites of Z. There appears to be rapid metabolism and elimination of Z from the body, but changes in the reproductive organs persist up to 1 wk after dosing. For example, after dosing with 3.5 mg of Z per kilogram body weight, gilts were found to have enlarged uteri and cervixes, in some cases up to four times the size of controls.

A research contract is under way to draw together all existing data on the incidence and effects of mycotoxins in Canada. These data will be used to better identify those mycotoxins of primary concern to Canadian agriculture.

### Rapeseed oil nutrition

Studies are continuing to elucidate the cause of heart lesions in male rats fed high fat diets. In previous work, there appeared to be no relationship between levels of free fatty acids in the myocardium and heart lesions. With the availability of a new method,

developed to measure cardiac free fatty acids in the absence of lipolysis, it was demonstrated that the cardiac free fatty acid levels were very low and not significantly different between several vegetable oils and LEAR (low erucic acid rapeseed) oils. The erucic acid content at less than 5% in the diet also had no effect on the levels of cardiac free fatty acids. The cardiac triglyceride composition, as expected, reflected the dietary fatty acid composition.

The cardiac phospholipid content remained fairly constant irrespective of the age of the rat and diet. However, significant changes in the fatty acid composition occurred within the major cardiac phospholipids due to different dietary fatty acids. Dietary oleic acid specifically affected cardiac sphingomyelin and cardiolipin composition, while dietary linoleic and linolenic acids had a dramatic effect on the C<sup>22</sup> polyunsaturated fatty acids of phosphatidyl ethanolamine and phosphatidyl choline. Despite these changes, a regulation of fatty acid composition was evident within the cardiac phospholipids, presumably to maintain the structural integrity of cardiac membranes.

The etiology of the heart lesions is not completely understood. The lesions could not be related to possible cardiopathogenic agents present in fully refined vegetable oils. Further research has shown that pure triglycerides, prepared from soybean oil and LEAR oil of the cultivar Tower by molecular distillation and column chromatography, gave similar cardiopathological results to the original oils from which they were purified. This study was carried out concurrently at the Veterinary College of the University of Saskatchewan, the Animal Diseases Research Institute (Ottawa), and the Animal Research Institute, and no significant differences were observed among the three establishments. The results support previous Institute findings that in rats the cardiopathogenicity of the test oils resides in the triglycerides of the oils.

A relationship was found, however, by pooling the results of 23 experiments involving cardiopathological examination of male albino rats fed high fat diets for 4–6 mo at four independent laboratories. Regression analyses carried out in cooperation with the Engineering and Statistical Research Institute showed that myocardial lesions in male albino rats appear to be related to levels of certain dietary fatty acids. Palmitic, stearic, and linoleic acids were negatively correlated

to heart lesions, while linolenic, oleic, and erucic acids were positively correlated. Experiments are in progress to establish the relationship of some of these fatty acids to heart lesions in male rats.

### Pesticide metabolism

*Atrazine.* A metabolic pathway for atrazine in chickens was established from combined in vitro and in vivo studies in a cooperative project with the Chemistry and Biology Research Institute. Identification of the herbicide and three metabolites permitted postulation that in the chicken metabolism proceeds mainly by partial *N*-dealkylation accompanied by hydrolysis. Species differences in metabolic pathways were noted when in vitro studies were extended to liver enzyme preparations from goose, pig, and sheep.

Studies also showed that no residues of the herbicides or metabolites occurred in corn silage or grain corn crops grown where atrazine had been applied at the recommended rate for several years. Consumption of these feeds by dairy cattle and poultry, therefore, would not result in objectionable residues of atrazine and metabolites in milk, eggs, or edible meat.

*Tetrachlorvinphos.* In vitro metabolism studies with chicken liver enzyme preparations indicated that the primary step was glutathione-dependent demethylation followed by hydrolysis and further conjugation to polar compounds which can be excreted. Similar studies with liver preparations from goose, turkey, sheep, pig, and cow revealed species differences. In the goose, isomerization of the insecticide also occurred in addition to the normal metabolic pathways observed in the other species. In in vivo studies with lactating cows it was found that the insecticide was almost totally (82.2%) eliminated in the urine after 10 days as five metabolites, two of which were in both free and conjugated forms. In addition, unchanged insecticide (7.1% of the dose) and the alcohol metabolite (8.9%) were excreted in the feces. Neither unchanged insecticide nor metabolites could be detected in milk or various tissues 10 days after cessation of oral administration of the insecticide. A metabolic pathway in lactating cows was proposed which contained several steps also identified in in vitro studies.

*Fenvalerate, decamethrin, and cypermethrin.* Studies on the metabolism of these

synthetic pyrethroids are under way. Fenvalerate has been synthesized and purified by separation into its *cis*- and *trans*-isomers. Twelve metabolites and the insecticide with <sup>14</sup>C-labels at two positions have been synthesized and purified. Gas-liquid chromatographic data and nuclear magnetic resonance and mass spectroscopic data have been obtained for these standards to assist in later

identification. Metabolic pathways and residue data will result from combined *in vivo* and *in vitro* studies in farm animals and poultry.

*Trichlorfon*. *In vitro* studies resulted in five metabolites which, when identified, provided further evidence of a complex metabolic pathway. Analyses of samples from *in vivo* studies in chickens are under way.

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D. E. BRIGHT, B.S., M.S., Ph.D.	Scolytidae (bark beetles), Curculionidae (weevils)
E. C. BECKER, B.S., M.S., Ph.D.	Elateridae (click beetles, wireworms)
P. DANG, <sup>2</sup> B.S., M.S., Ph.D.	Microlepidoptera of forest importance (spruce budworm)
J. D. LAFONTAINE, B.A., Ph.D.	Noctuidae (cutworm moths)
L. LESAGE, B.S., M.S., Ph.D.	Chrysomelidae (leaf beetles) and larval Coleoptera
A. MUTUURA, B.Sc., Ph.D.	Tortricidae (leafroller moths)
F. SCHMID, Lic. ès Sc. Nat., D. ès Sc. Nat.	Trichoptera (caddisflies)
A. SMETANA, M.U.DR., Cand. Sc. Biol.	Aquatic beetles, Staphylinidae (rove beetles)

## Diptera and Hemiptera

D. M. WOOD, B.A., M.A., Ph.D.	Head of Section; Tachinidae (parasitic tachinid flies), Culicidae (mosquitoes)
K. G. A. HAMILTON, B.S.A., M.Sc., Ph.D.	Cicadellidae (leafhoppers), Cercopidae (spittlebugs)
L. A. KELTON, B.S.A., M.Sc., Ph.D.	Miridae (plant bugs), Anthocoridae (flower bugs)
J. F. MCALPINE, B.S.A., M.Sc., Ph.D.	Lonchaeidae (lance flies), Chamaemyiidae (silver flies)
D. R. OLIVER, B.A., M.A., Ph.D.	Chironomidae (nonbiting midges)
R. V. PETERSON, B.S., M.S., Ph.D.	Simuliidae (black flies), Nycteribiidae and Streblidae (bat flies)
W. R. RICHARDS, B.Sc., M.Sc., Ph.D.	Aphidoidea (aphids, plant lice), Psyllidae (psyllids), Coccoidea (scale insects), Thysanoptera (thrips), Psocoptera (psocids, booklice), Collembola (springtails)
H. J. TESKEY, B.Sc., M.S.A., Ph.D.	Tabanidae (horse flies, deer flies), dipterous larvae
J. R. VOCKEROTH, B.A., M.A., D.Phil.	Syrphidae (flower flies), Scatophagidae (dung flies)

## Experimental Taxonomy and Nematology

R. V. ANDERSON, B.A., M.S., Ph.D.	Head of Section; Hoplolaimidae (spiral nematodes), Tylenchorhynchidae (stylet nematodes), Aphelenchoidea (foliar nematodes)
J. W. ARNOLD, B.A., M.Sc., Ph.D.	Insect hemocytology
J. R. BYERS, B.S.A., M.Sc., Ph.D.	Reproductive biology and behavior of cutworm moths
B. A. EBSARY, B.Sc., M.Sc., Ph.D.	Criconeematidae (ring nematodes), Paratylenchidae (pin nematodes), Hemicycliophoridae (sheath nematodes)
B. N. A. HUDSON, B.Sc., Ph.D.	Chemical taxonomy of insects: polymorphic enzymes
R. MATSUDA, B.A., Ph.D., D.Sc.	Comparative morphology, Tingidae (lace bugs), Aradidae (flat bugs)
E. H. SALKELD, B.S.A., M.S.A., Ph.D.	Comparative micromorphology of insect eggs

## Hymenoptera and Arachnida

I. M. SMITH, B.Sc., Ph.D.	Head of Section; Acari (mites)
J. R. BARRON, B.Sc., M.Sc., Ph.D.	Ichneumonidae (ichneumon wasps)

C. D. DONDALE, B.Sc., M.Sc., Ph.D.  
 H. GOULET, B.A., B.Sc., M.Sc., Ph.D.  
 E. E. LINDQUIST, B.S., M.S., Ph.D.  
 C. C. LOAN, B.A., M.S., Ph.D.  
 L. MASNER, B.Sc., M.Sc., Ph.D.  
 W. R. M. MASON, B.Sc., Ph.D.  
 C. M. YOSHIMOTO,<sup>3</sup> B.A., M.Sc., Ph.D.

Araneae (spiders), Opiliones  
 (harvestmen)  
 Symphyta (sawflies)  
 Acari (mites, ticks)  
 Ichneumonidae (ichneumon wasps),  
 Braconidae (braconid wasps)  
 Proctotrupeoidea (proctotrupid  
 wasps), Bethyloidea (bethylid  
 wasps), Sphecoidea (digger wasps),  
 Evanioidea (ensign wasps)  
 Braconidae (braconid wasps)  
 Chalcidoidea (chalcid wasps),  
 Cynipoidea (cynipid wasps)

### Mycology: Plant Disease and Biodegrading Fungi

R. A. SHOEMAKER, B.S.A., M.S.A., Ph.D.	Head of Section; Ascocarpic parasites of cereals
D. J. S. BARR, B.Sc., M.Sc., Ph.D.	Zoosporic parasites of vegetable crops
J. D. BISSETT, B.Sc., Ph.D.	Conidial parasites of forage crops
M. P. CORLETT, B.A., M.A., Ph.D.	Ascocarpic parasites of fruit crops
J. H. GINNS, B.S., M.S., Ph.D.	Curator of National Collection of Fungus Cultures; Basidiocarpic tree wood rots
S. J. HUGHES, B.Sc., M.Sc., D.Sc., F.L.S., F.R.S.C.	Conidial molds of wood and insects
G. A. NEISH, B.Sc., Ph.D.	Mycotoxin fungi
J. A. PARMELEE, B.Sc., M.A., Ph.D.	Curator of National Mycological Herbarium; Obligate parasites of plants (rusts, smuts, mildews)
S. A. REDHEAD, B.Sc., M.Sc., Ph.D.	Mushrooms

### Vascular Plants

E. SMALL, B.A., B.Sc., M.Sc., Ph.D.	Head of Section; Cultivated crops, <i>Medicago</i>
S. G. AIKEN, B.Sc., M.Sc., M.S., Ph.D.	Grass flora of Canada
I. J. BASSETT, B.A.	Hay-fever plants, palynology, weeds
B. R. BAUM, M.Sc., Ph.D.	Cultivated crops, <i>Hordeum</i>
W. J. CODY, B.A.	Curator of Herbarium, Canadian flora, ferns
F. W. COLLINS, B.Sc., Ph.D.	Chemotaxonomy, <i>Brassica</i>
J. MCNEILL, B.Sc., Ph.D.	Weeds, Polygonaceae, Caryophyllaceae
G. A. MULLIGAN, B.Sc.	Weeds, Cruciferae
S. I. WARWICK, B.Sc., Ph.D.	Weeds, genecology

## Honorary Research Associates

C. FRANKTON, B.Sc., Ph.D.	Weeds, Polygonaceae
D. F. HARDWICK, B.A., M.Sc., Ph.D.	Noctuidae (cutworm moths)
G. P. HOLLAND, B.A., M.A., D.Sc., F.R.S.C.	Siphonaptera (fleas)
R. MACRAE, B.A., M.Sc., Ph.D.	Basidiocarpic wood rots, polypores
W. C. MCGUFFIN, B.A., M.A., Ph.D.	Geometridae (geometer moths, loopers)
R. H. MULVEY, B.Sc., M.S.	Heteroderidae (cyst nematodes), Meloidogynidae (root-knot nematodes), Tylenchidae (spear-bearing nematodes)
E. G. MUNROE, B.Sc., M.Sc., Ph.D., F.R.S.C.	Pyralidae (pyralid moths)
M. K. NOBLES, B.A., M.A., Ph.D., F.R.S.C.	Basidiocarpic wood rots, hymenomycetes
O. PECK, B.Sc., M.Sc., Ph.D.	Chalcidoidea (chalcid wasps)
D. B. O. SAVILE, B.S.A., M.Sc., Ph.D. D.Sc., F.R.S.C.	Plant rusts
G. E. SHEWELL, B.Sc., M.Sc.	Lauxaniidae (lauxaniid flies), Calliphoridae (blow flies)
G. S. WALLEY, B.S.A., M.S.	Ichneumonidae (ichneumon wasps)
A. WILKES, B.S.A., M.Sc., Ph.D.	Insect genetics

## Departures

B. BOIVIN, L.Sc., B.A., Ph.D., F.R.S.C. Transferred to Sainte-Foy Research Station, Qué.	Flora of Canada
R. H. MULVEY, B.Sc., M.S. Retired December 1979	Heteroderidae (cyst nematodes), Meloidogynidae (root-knot nematodes), Tylenchidae (spear-bearing nematodes)
E. G. MUNROE, B.Sc., M.Sc., Ph.D., F.R.S.C. Retired September 1979	Pyralidae (pyralid moths)
L. K. WERESUB, B.A., M.A., Ph.D. Deceased	Basidiocarpic humus-formers and crop psychrophils

<sup>1</sup>Seconded from Libraries Division, Finance and Administration Branch.

<sup>2</sup>Seconded from Forestry.

<sup>3</sup>Seconded from Environment Canada.

## INTRODUCTION

The Biosystematics Research Institute provides a national identification service for Canadian insects, arachnids, nematodes, vascular plants, and fungi. To meet this responsibility, the Institute conducts research on various aspects of biosystematics and maintains custody of the National Mycological Herbarium, the National Mycological Culture Collection, the Agriculture Canada Vascular Plant Herbarium, and the Canadian National Collection of Insects, Arachnids, and Nematodes.

The Institute emphasizes the production of identification manuals on the flora and fauna of Canada and taxonomic studies on organisms of economic importance. During this year, we initiated annotated inventories of the pest species of plants, fungi, and insects found in Canada.

Dr. I. M. Smith replaced Dr. J. R. Barron as Head of the Hymenoptera and Arachnida Section and Dr. R. V. Anderson became Head of the Experimental Biology and Nematology Section when Dr. J. R. Byers stepped down.

Reprints of research publications are available from the authors. Correspondence on other matters should be addressed to Director, Biosystematics Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

G. A. Mulligan  
Director

## IDENTIFICATIONS, COLLECTIONS, AND SURVEYS

### National Identification Service

A total of 74 109 specimens of insects, arachnids, and nematodes were identified during 1979. Parks Canada (35%), Agriculture Canada (11.7%), and Canadian universities (11.8%) were the greatest users. Some 6000 specimens were received from the general public for identification, general information, or control measures.

During 1979, 15 205 collections of vascular plants were received for identification and 14 140 collections were identified. Canadian and American universities were the major users of this service (26.0% and 26.4%, respectively), followed by other federal departments (20.9%). An increased number of inquiries was received directly from the general public and through the Public Services Section, Information Services, Agriculture Canada. Assistance was provided to the Poison Control Centre for nine cases of suspected poisoning from vascular plants.

A total of 3082 collections and cultures of fungi were received for identification during 1979, and 2819 were identified. Principal users of the service were other federal departments (38%), followed by the general public (24.3%), Agriculture Canada (12.9%), and Canadian universities (11.1%). Assistance

was provided to the Poison Control Centre for 53 cases of suspected poisoning from mushrooms.

### Collection development

The holdings of the Canadian National Collection of Insects, Arachnids, and Nematodes increased by some 550 000 specimens. Twenty-three officers of the Institute collected in various parts of Canada and the United States: British Columbia, Manitoba, Ontario, Quebec, Newfoundland, California, Washington, Oregon, Arizona, New Hampshire, and Vermont. Donations of specimens to the collection totaled some 99 000 specimens and purchases amounted to 2000. Loans to 162 institutions around the world amounted to 46 360 specimens being forwarded for research study. Material incorporated into the collection totaled some 230 000 specimens.

The holdings of the Vascular Plant Herbarium now stand at 677 041 collections, an increase of 16 404 during 1979. Approximately 8400 collections were made by staff members, and 4797 collections were donated, 4597 as exchanges and 200 as gifts from other herbariums.

The holdings of the National Mycological Herbarium stand at 223 372 specimens, an increase of 2884 accessions during the current year. A total of 810 specimens were donated, 800 as exchange and 10 as gifts. Approximately 3679 collections were made by staff

## Zoological and botanical identifications for 1979

	Arthropods and nematodes, number of specimens	Vascular plants collections <sup>1</sup>	Fungi collections <sup>1</sup>	Fungi <sup>2</sup> cultures <sup>2</sup>	Total
<b>Canada</b>					
Agriculture Canada	8 638	490	138	226	9 492
Environment Canada	6 198	751	44	19	7 012
Other federal departments	29 064	2 959	1 034	38	33 095
Provincial departments	4 775	435	56	44	5 310
Industry	35	9			44
Universities	8 759	3 677	244	68	12 748
General public	5 658	483	686		6 827
<b>USA</b>					
Government departments	2 053	1 245	48	4	3 350
Universities	4 953	3 734	48	7	8 742
General public	963				963
<b>Other countries</b>	3 014	357	98	17	3 486
<b>Total</b>	74 110	14 140	2 396	423	91 069

<sup>1</sup>The term collection refers to all of the plants or fungi of one species that were collected at a certain location at one time and may in fact consist of from one to more than a thousand individuals.

<sup>2</sup>The term culture denotes a living fungus population aseptically cultivated on various substrata under different conditions, usually to obtain identifiable structures of different states in the life cycle.



members during the year, but most of these have not yet been incorporated. The National Collection of Fungus Cultures has increased its holdings from 5732 to 6093, an increase of 261 cultures. These cultures were received from other institutions for deposit, through the Identification Service, or from isolations made by staff members. The culture collection contains a total of 453 genera and 1159 species of fungi, and at present 1801 cultures have been successfully lyophilized for long-term preservation.

### Riding Mountain National Park survey

During the summer of 1979, the Institute carried out a 4 mo survey of the insects, vascular plants, and fungi of Riding Mountain National Park, Man. The purpose of the survey was to collect specimens pertinent to the research interests of the Institute and to enhance the collections. This park was selected because it represents a meeting point for three elements of the Canadian flora and fauna. Northern boreal forest, eastern deciduous forest (parkland), and western shortgrass prairie are all represented within the area of the park. Two zoology and two botany technicians were present in the park throughout the survey period and many scientists participated on a short-term basis. The material collected is in the process of being sorted and prepared and will be incorporated into the collections. An effort was made to provide biological information to the National Park staff.

### Identification aids

*Insects and Arachnids of Canada.* This faunal series was initiated several years ago and is now established as an Institute activity. This activity is designed to treat the insect and arachnid fauna of Canada in a series of books that will permit the nontaxonomic biologist to identify various arthropod entities. Since the last annual report two contributions were published, *The Crab Spiders of Canada and Alaska (Araneae: Philodromidae and Thomisidae)* and *The Mosquitoes of Canada (Diptera: Culicidae)*. The spider handbook describes the 110 species of crab spiders found or suspected of occurring in Canada and Alaska. Taxonomic keys and illustrations help the user to identify the various genera and species of spiders. The mosquito publication is intended for those wishing to identify adult mosquitoes and their larvae. Descriptions and keys are provided for the 74 species

found in Canada. Patterns of seasonal occurrences and geographical distribution of mosquitoes are discussed. Techniques for collecting, rearing, and preparing specimens as well as a discussion of anatomical terms and a glossary are included in both handbooks.

*Plant-parasitic nematodes in Canada.* Part 1 of this series, *An Illustrated Key to the Genera*, was published during 1979. The nematode genera are grouped by family and their diagnostic features are defined and illustrated by labeled photomicrographs. The key, which is presented in tabular form, will aid in identifying 52 Canadian genera of nematodes and will serve as a guide and basic reference for a subsequent series of keys to be published on the species of plant nematodes by family groups. Nearing completion are illustrated keys to the Canadian species of the families Hoplolaimidae, Tylenchorhynchidae, and Heteroderidae.

*The Species Problem in Cannabis: Vol. 1 Science, Vol. 2 Semantics.* This two-volume work reviews the complexities of the species problem in *Cannabis* and subsequent legal implications.

*Edible and Poisonous Mushrooms of Canada.* A revision of this identification guide containing keys to all the genera and species of mushrooms found in Canada was published during 1979. Black-and-white and colored illustrations are included as well as descriptions of the mushrooms, habitats, fruiting periods, distinguishing characteristics, and their edible or poisonous characteristics.

*The Biology of Canadian Weeds, 1-32.* This volume contains a detailed summary of biological information on 41 species of Canadian weeds.

*Fungi Canadenses.* During 1979, 30 contributions to *Fungi Canadenses* were published, bringing the total in this series to 160. An additional 30 contributions are being processed. The taxa illustrated and described include two new species and one new combination. Species described include parasitic and biodegrading fungi in the following genera: *Acrophragmis*, *Apiothyrium*, *Capnobotrys*, *Dendryphon*, *Didymella*, *Endophragma*, *Gymnosporangium*, *Mariannaea*, *Melampsora*, *Paecilomyces*, *Phaeomarasmius*, *Phragmocephala*, *Psathyrella*, *Pseudosporopes*, and *Rostelia*. *Fungi Canadenses* is distributed to 100 Canadian institutions, and

350 copies are sent to universities and research establishments in 51 other countries.

## SECTIONAL RESEARCH

### Coleoptera, Lepidoptera, and Trichoptera

*Coleoptera*. Staphylinidae—A revision of the genus *Tachyporus*, treating 38 species, was published. A paper revising the three species of the genus *Carphacis* was submitted for publication, and a memoir-sized paper treating the 36 species of *Lordithon* was completed. A rough draft of the revision of the subfamily Xantholininae, treating 26 genera and over 100 species, was finished and four additional papers pertaining to this activity were published or submitted for publication. Preliminary work was initiated on revisions of the genera *Olophrum* and *Acidota*.

Hydrophilidae—A revision of the genus *Hydrochara* of the world, treating 21 species, was finished and accepted for publication. A paper containing supplements to the previously published revision of the subfamily Sphaeridiinae was published. A manuscript treating the three species of the genus *Chaetarthria* for the handbook series *The Insects and Arachnids of Canada* was completed.

Alleculidae—All keys were completed for a handbook of the Alleculidae and Lagriidae for the series *The Insects and Arachnids of Canada*.

Scolytidae—A monograph of the genus *Pityophthorus* was completed and submitted for publication. The genus contains 233 species which are divided into six subgenera.

Buprestidae—Keys to all genera and species for the handbook series *The Insects and Arachnids of Canada* were completed, and complete species treatments in seven genera were finished.

Miscellaneous—Approximately one-half of the bibliographic search for an inventory of the pest species of Coleoptera of agricultural importance was completed. Handbooks on the histerid beetles (Histeridae) and flea beetles (Chrysomelidae) were nearly completed, and a handbook on the scarab beetles (Scarabaeidae) was initiated.

*Lepidoptera*. A revision of the *Euxoa detersa* group (Noctuidae), with 33 included

taxa, was completed. The paper includes a biogeographic analysis of the species group in North America and a phylogenetic analysis of the genus *Euxoa*. Work on a catalog of Noctuidae of Central and South America was initiated. A paper revising the North American species of the genus *Dioryctria* and a paper dealing with a new species of the apple leaf miner *Phyllonorycter* were published. Three papers on newly introduced tortricid moths (Tortricidae), as well as one paper describing a new method using the sclerotized and pigmented areas of muscle attachments for larval classification of Tortricidae were submitted for publication. A paper on larval taxonomy of the 35 species of Pyraustini, including agricultural pests such as the European corn borer, the beet webworm, and the garden webworm, and a paper dealing with the larval stages of the gooseberry fruitworm *Zophodia convolutella* were completed. The final draft of the third part of the subfamily Eunominae for the *Guide to the Geometridae of Canada* was completed. It includes the tribes Baptini, Caberini, Angeronini, Nacophorini, Campaeini, and Epirranthini.

*Trichoptera*. The third part of the handbook of Trichoptera of Canada, dealing with the families Philopotamidae and Glossosomatidae, was completed. One paper discussing new trends in the study of Trichoptera was published, and two other papers on the classification and phylogeny of the family Goeridae and the genus *Archithremma* were completed.

### Diptera and Hemiptera

The first volume of *Manual of Nearctic Diptera*, covering over 700 genera in 43 families, is in press. Comprehensive reviews of the anatomy and terminology standardize the usage of all morphological terms throughout the Diptera. Keys to larvae and adults of all families, as well as keys to all genera of each family, all illustrated with over 1500 original figures, should enable anyone to identify to the generic level any fly found anywhere in Canada or the United States. The bulk of the manuscript of Volume 2, covering nearly 1200 genera in 65 families, has been completed.

A handbook to the genera of the larvae of Canadian midges (Chironomidae) was completed. The larvae of midges, which are nearly all aquatic, are among the most important indicators of water quality. Keys to the

subfamilies and genera, illustrated with several hundred photomicrographs, should enable the reader to identify to genus any chironomid larva in Canada.

A handbook on the spittlebugs of Canada provides keys and illustrations to facilitate the identification of all 37 species of spittlebugs (Cercopidae) known to occur in Canada, as well as six others that could occur here. Each species description is accompanied by records of host plants and a map of its distribution in Canada.

Volume 1 of a planned two-volume work, which treats the genera of Aphidoidea in Canada, is being reviewed. Additional handbooks in preparation will treat the leafhoppers of fruit and ornamental trees, plant bugs of fruit trees, aphids and scales of fruit crops, aphids and thrips of cereal and forage crops, and aphids and thrips of vegetable crops.

Cooperation continued with the World Health Organization in their drive to facilitate identification of the black fly vectors (Simuliidae) of onchocerciasis in West Africa. Formerly recognizable only by banding patterns of their giant chromosomes, both males and females of six species can now be distinguished by subtle external differences. A new pictorial key was designed to enable technicians in West Africa to identify these vectors. Among the specimens of black flies studied was one which was a bilateral gynandromorph—male on one side, female on the other. A detailed study of this specimen, which allows one to homologize various structures between the two sexes, is in press.

Five taxonomic revisions of various plant bugs (Miridae) added 1 new genus, 9 new species, and 15 new combinations. Revisions of the New-World species of the major leafhopper genera *Idiocerus* and *Macropsis* added 29 new species and many new host records. A review of the world genera of the spittlebug subfamily Aphrophorinae was completed, covering 17 tribes, 68 genera, and 1028 species, including 33 new species and 353 new combinations. Four faunal papers on spittlebugs were submitted for publication; these contain 2 new genera, 67 new species, and 31 new combinations.

A detailed study of the head structure of representative Hemiptera resulted in a new interpretation of the structure formerly known as the postclypeus; it was identified as the frons. The reinterpretation strengthens the hypothesis that Hemiptera were descended from psocopteroid-like ancestors.

This reinterpretation bridges the evolutionary gap between the mandibulate mouthparts of the Psocoptera and the piercing and sucking mouthparts of the Hemiptera.

## Hymenoptera and Arachnida

*Hymenoptera.* A chapter reviewing taxonomic and faunistic knowledge of Hymenoptera in Canada was published in the volume *Canada and its Insect Fauna*, a memoir of the Entomological Society of Canada. Further progress was made on three contributions of Hymenoptera for the series *The Insects and Arachnids of Canada* with the introductory volume and the section on sawflies being partially drafted and the manuscript on chalcidoid wasps being completed for internal review. An important review of the higher classification of Hymenoptera was initiated to validate the taxonomic framework to be adopted for the faunal manual.

Symphyta—Work is nearly completed on the sawfly subfamily Nematinae for inclusion in the identification manual. Substantial progress was made in the study and evaluation of species diagnostic characters for the revision of the genus *Dolerus*. Techniques for associating immature and adult instars of sawflies were further investigated.

Braconidae—A manuscript was completed for internal review on a major revision of the subfamily Microgastrinae, a large and difficult group of parasites of Lepidoptera. A manuscript presenting data on species of Euphorinae parasitic on plant bugs was completed.

Ichneumonidae—A large manuscript dealing with a revision of the Nearctic species of *Ctenopelma* is nearly completed. A revision of the large genus *Rhorus* based upon study of both larvae and adults is under way. Research on the old-world fauna of the genus *Euceros* was published. Studies on the Nearctic species of the tryphonine genera *Neliopisthus* and *Oedemopsis* are continuing.

Chalcidoidea—A manuscript including a redescription of the unusual species *Tetracyclos boreios*, with a discussion of its morphology and taxonomic placement, was submitted. A synopsis of the Nearctic species of the genus *Chrysonotomyia* was completed.

Proctotrupoidea—A large manuscript providing keys to the Holarctic genera of the

family Scelionidae was submitted for publication and research leading to published keys to the genera of Platygastriidae is under way. Revision of the Nearctic fauna of the genus *Calotelea* was completed. Studies of the species of *Oethecoctonus*, *Metaclisis*, and *Acerotella* are nearing completion. Further substantial progress was made on the design and testing of sampling devices for microhymenoptera. These advances are resulting in a marked increase in the representation of many species in the research collection.

*Arachnida*. Three chapters reviewing taxonomic and faunistic knowledge of arachnids in Canada were published in the volume *Canada and its Insect Fauna*, a memoir of the Entomological Society of Canada.

*Araneae*—A revision of the Nearctic wolf spiders of the genus *Alopecosa* was published. The faunal manual for the sac spiders of Canada and Alaska is in final stages of preparation. Research on the North American species of the wolf spider *Arctosa* and *Pardosa* is in progress.

*Acari*—An important paper on the evolution of phytophagous mites was published in the volume *Annual Review of Entomology*. A major manuscript on the genera of the family Tarsonemidae, representing probably the most comprehensive study yet attempted on a family of mites, is nearly complete. A manuscript reviewing the species of the water mite family Anisitsiellidae was published. Substantial progress was made on studies of the species of the eriophyoid genus *Trisetacus*, important pests of coniferous trees, and a large manuscript will soon be completed.

### Experimental taxonomy and nematology

*Biosystematics of cutworms*. Starch-gel electrophoresis techniques were further refined to detect species-specific isozymes using only one leg, thereby permitting retention of moths for reference or further study. By this technique and morphometric analysis, the existence of two discrete species within the nominal species of the spotted cutworm, *Amathes c-nigrum*, was demonstrated, confirming the diagnostic value of certain isozymes. Observations of reared and field populations have indicated interspecific differences in the duration of larval and pupal stages, and suggest that the isolating mechanism between the two species includes a temporal factor.

Cells of different types found in the hemocyte complex of Noctuidae may vary widely in size, form, and character. Completed studies of 75 species of 36 genera show some common features at the subfamily level which make the present taxonomic position of certain species less tenable. Evidence suggests also that certain anomalies in the hemocyte complex of some species may be of no taxonomic or phyletic significance, but rather reflect specific hemophysiological requirements peculiar to species biology.

Temporal partitioning of circadian mating activity among the three closely related species of *Euxoa* cutworm moths in the *declarata* group was shown to be maintained under the various temperature regimes likely to occur in nature. When the mating-activity rhythms of the three species are experimentally synchronized by manipulation of the photoperiod, their sex attraction pheromones are highly cross-attractive. No chemical differences among the sex pheromones of the three species could be detected. This is the first demonstration that reproductive isolation between interfertile, sympatric, and seasonally synchronic species of moths lacking species-specific pheromones can be maintained by temporal differences in activity rhythms.

*Insect morphology*. Scanning micrographs and descriptions of the eggs of 131 species of Canadian geometrids were prepared and submitted for publication. Relationships indicated by chorionic characters are discussed at each taxonomic level and compared to those based on larval and adult morphology. The eggs possessed characters of value at the specific and generic level, and usually at the tribal level. However, no feature or combination of features was found which could be considered characteristic of the subfamilies.

Continuing morphological studies of the nymphs of lace wing insects (Tingidae) indicate that differences in form, structure, and color patterns of spines are of diagnostic value for distinguishing species with similar adults. A new theory of evolution in arthropods proposing an environment-hormonal mechanism for induction of evolutionary change is being advanced to include a broader spectrum of animal groups.

*Nematology*. A new abullate species of cyst-forming nematode (*Heterodera*) attacking spike-rush, a new host record for nematodes, was described and published. Its relationships to the *goettingiana* group were clarified and a taxonomic key provided to the 15 nominal species. Also published were descriptions of two new species of ring nematodes of the genus *Criconemoides*, a new taxon record for Canada, and *Crossonema*, including first descriptions of diagnostic juvenile characters for other species. Nearing completion is a revision of the Criconematidae, which proposes new genera and species with keys to aid in their identification.

Completed or in press are taxonomic and morphological studies of five species of plant nematodes. Described from Canada are a new genus of cyst-forming and a species of root-knot nematodes, which includes a host record and a key to related species based on characters of the infective larvae. In press are the description, relationships, and host symptoms of a new species of *Ditylenchus* which produces leaf galls that have evolutionary and phyletic implications. A new diagnostic feature of the reproductive system characterizing a new, terrestrial species of *Aphelenchus*, when compared in specimens from 110 populations in 30 countries, permits grouping of species for which new subgenera are proposed. Features of the lip region of the root-lesion nematode, *Pratylenchus penetrans*, from three host plants proved to have no diagnostic value in identifying Canadian species and species complexes. Labial configuration, resolved by scanning micrographs, varied markedly with the host and transcended those reportedly diagnostic for other species.

#### **Mycology: plant disease and biodegrading fungi**

Cultural studies, including ultrastructural observations of zoospores, have shown that chytridiaceous fungi can be divided among the older order Chytridiales and a new order encompassing the genera *Entophlyctis*, *Olpidium*, *Rhizophlyctis*, and the *Phlyctochytrium* complex; this complex is to be divided into four new genera. It was confirmed that *Polymyxa*, a genus of plant parasitic fungi which transmit virus diseases, consists of two species, *P. graminis* and *P. betae*, and these can be subdivided into *formae speciales*.

*Paecilomyces*, a genus of insect pathogens, was monographed for Canada. One new species was described (*P. breviramossus*) and one species was recorded for the first time from Canada (*P. tenuipes*). A study on *Phyllosticta* and related genera on Liliales was completed. Two new species of *Phyllosticta* were described (*P. crypta* and *P. cumminsii*), both parasitic on *Smilax* in North America. More than 100 strains of *Trichoderma* were studied in culture in 1979. High-resolution scanning electron microscope techniques were implemented to study the conidial surface of *Trichoderma* species. A manuscript entitled "Long term effects of fire on the composition and activity of the soil microflora of a subalpine, coniferous forest" was submitted for publication, completing a study with Parks Canada. Three papers were published on the distribution, community structure, and effects of environment on soil fungi in alpine tundra.

A taxonomic revision of the species of the genus *Didymella* (parasites of raspberry, cucurbits, grasses, and legumes) is close to completion. A joint study with Dr. W. B. Berkenkamp, Research Station, Lacombe, on the taxonomy of the hyphomycetous genus *Stemphylium* parasitic on legumes, with emphasis on forage legumes of Western Canada, is under way.

A monograph of the genus *Flaviporus* was completed. Emphasis was placed on the description of microscopic features and comparison of the genus with the similar *Rigidoporus*. A revision of *An Annotated Index of Plant Diseases in Canada*, now 20 yr old, was begun. When completed it will contain a substantial number of new entries as well as contemporary taxonomic treatment of the fungus names. A new species of mushroom was described (with mycologists from the University of Toronto). It was found decaying mine timbers in Ontario. A study of the genus *Cyptotrama* section *Xerulina* in North America was completed.

Collaborative work with Animal Research Institute scientists on the occurrence of *Fusarium* species and their toxins in overwintered maize is being continued with the inclusion of detailed examination of field plots. Experiments on macroconidium germination by *Fusarium acuminatum* has demonstrated that oxogenous carbon sources have a marked quantitative effect on the production of microconidia by germinating macroconidia. Work on the examination and evaluation of

the *Fusarium* collections in the Gordon Herbarium, an important Canadian collection, has been initiated.

Work was completed on taxonomic treatments of the mold genera *Rhinocladium*, *Endophragma*, *Hadrosporium*, and *Guedea*.

Seven short articles on the classification of rust fungi (Uredinales) were submitted for a work on classification of living organisms. In cooperation with R. Cauchon, Laurentian Forest Research Centre, a report of the first occurrence of the fungus *Strasseria* on Pinaceae in North America was published. Rusts of the hollyhock family (Malvaceae) and the potato family (Solanaceae) were described.

Field work on mushrooms (Agaricales) in the national parks of British Columbia, Manitoba, and New Brunswick resulted in the discovery of at least three new species, four new North American records, and numerous new Canadian records. Publications were prepared on fungal parasitism, nomenclature, and generic monographs involving one new genus, nine new combinations. A popular mushroom book was updated.

Progress was made on the genus *Leptosphaeria* through additional collections in Western Canada.

The manuscript for a handbook of poisonous mushrooms in Canada was completed for Agriculture Canada under a contract with the University of Toronto.

### Vascular plants

*Hops*. A study detailing the relationships of wild and cultivated hops of Japan, North America, and Europe was accepted for publication. It was shown that cultivars of the three geographical regions are morphologically distinguishable and are very similar to indigenous wild races in the respective areas. A further study examining methods of discriminating cultivars of different regions of the world on the basis of commercial samples of hops is nearing completion.

*Alfalfa*. Hundreds of populations of alfalfa, *Medicago sativa* L., and related species have been grown to provide study materials. Morphological, numerical, palynological, floral, and chemical studies are now in progress, and initial results indicate these disciplines provide valuable characters for systematic purposes.

*Blueberries*. Supervision of contracted production of a monograph on the genus *Vaccinium* in North America continued. During the

past year, distribution maps were made for the western and Arctic species, an account was completed of section *Vaccinium*, and drawings were prepared for the Appalachian sections.

*Oats*. A study of the possibility of identifying oat cultivars by means of pyrolysis-gas liquid chromatography yielded promising results. It appears that the method can be usefully applied as an adjunct to more common methods of identification.

*Barleys*. Work is progressing toward preparation of a world-wide barley cultivar registry, with pedigree and related information. Collecting expeditions to Argentina and Chile were completed, and much valuable material was collected. A comprehensive study of the *Hordeum jubatum* complex in Canada and Alaska was accepted for publication.

*Wheat group*. Investigations were conducted with regard to elucidating evolutionary relationships among the genera of the Triticeae, with a symposium address given on this topic being accepted for publication.

*Rape, cabbage, and allies*. Chemotaxonomic studies of the *Brassica napus* complex were continued, with emphasis on determining appropriate analytical methodology for assessing the presence of flavonol glycosides and glucosinolates. Data for a paper on this work have been obtained.

*Inventory of the cultivated crop plants of Canada*. Considerable literature and herbarium material was assembled toward compilation of an inventory, presenting essential information, on all plants known to be cultivated outdoors for crop purposes in Canada. Preliminary studies indicate that the inventory will treat about 400 species.

*Inventory of Canadian weeds*. Work was begun on the preparation of an inventory of Canadian weeds that will treat all weedy and otherwise noxious plants found in Canada. Common English and French names, correct scientific names, geographical distribution, and habitat will be briefly presented for each of about 1500 species.

*Biology of Canadian Weeds series*. An account of the biology of night-flowering catchfly (*Silene noctiflora* L.) was completed. This plant is an important annual weed, particularly of grain and leguminous crops in Western Canada. Also, an account of another

widespread pernicious weed, annual blue grass (*Poa annua* L.), was published.

*Ragweed.* A field survey of ragweed, *Ambrosia*, revealed a large hybrid population of *A. artemisiifolia* L.  $\times$  *trifida* L. in the Annapolis Valley of Nova Scotia. Chromosome counts varied between  $n = 18$  and  $n = 22$ . Studies of *Ambrosia trifida* showed that in self-pollinated plants, seed set was much reduced.

*Orach.* Nomenclatural and typification studies were carried out on several taxa of the widespread weed orach, *Atriplex*.

*Sandworts.* Studies of weedy sandworts, *Arenaria*, were conducted. Considerable progress was made on a publication detailing reasons for assigning the North American species of *Arenaria* to five genera rather than one.

*White cockle.* Studies of the inheritance and geographical distribution of two pollen types in the weed white cockle, *Silene alba* (Miller) E.H.L. Krause, were conducted. Genetic studies established that the features of one of the pollen types were dominant over those of the other. Both variants were found to occur widely in North America, but one is absent in the Prairie Provinces of Canada and in the midwestern United States, whereas in Europe, one variant is found in the east and the other in the west. It appears that the two pollen morphs have been introduced repeatedly into North America from different regions of the Old World.

*Water weeds.* Papers were published on the introduced weed water-milfoil, *Myriophyllum spicatum* L., and on the overwintering buds of the superficially similar native species *M. exalbescens* Fern. Chromosome counts for these two species and for *M. verticillatum* L. were published. Papers have been prepared and submitted for publication on the influence that substrate has on the growth and morphology of *M. spicatum* and *M. exalbescens*, on the discovery of *M. exalbescens* in Europe, and on the morphology of *M. alterniflorum* DC. in relation to substrate.

*Grasses of Canada.* A paper was published on *Stipa nelsonii* Scribner (commonly known as *S. columbiana*). Numerical taxonomic analyses established that this species contains three infraspecific groups. A key was also presented by which *S. nelsonii* can be distinguished from related species of *Stipa*. A

proposal to reject the name *Stipa columbiana* was prepared. An extensive monograph describing the Canadian species of *Stipa* was completed and accepted for publication.

As a result of the discovery in Ontario of a species of salt-meadow grass, *Diplachne acuminata* Nash, a paper was published resolving the confusion that has existed over the status of the closely related genera *Diplachne* and *Leptochloa* (sprangletops). Keys were provided to the two genera and the 13 species that occur in America north of Mexico.

Work was initiated on a generic key for identifying the grasses of western rangelands. Progress to date has involved the production of an attribute list of 85 characters that are being considered and an initial survey of approximately 50 of the species using this list. A computer program to analyze and produce a key to the data is being tested.

*Floristic studies.* A survey of vascular plants of restricted range in Continental Northwest Territories was published. Extensive colonies of watermeal, *Wolffia columbiana* Karst., a plant new to the flora of Manitoba, was discovered on beaver ponds in Riding Mountain National Park during a survey of the vascular plants of the Park.

*Genecological studies of weeds.* Experiments examining the response of contrasting growth forms of annual blue grass, *Poa annua* L., to common turfgrass herbicides were conducted and a manuscript was prepared. A manuscript was submitted for publication dealing with the inheritance of atrazine resistance of different biotypes of lamb's-quarters, *Chenopodium album* L. Reciprocal crosses indicated that there is uniparental inheritance of resistance through the female parent only. Studies were conducted examining the comparative biology of atrazine-resistant and -susceptible biotypes of lamb's-quarters. Results indicated that there are differences in growth and response to atrazine, not only between resistant and susceptible biotypes, but also within biotypes. Fifteen populations of lamb's-quarters, collected along an 800 km transect from Ottawa to Windsor, Ont., were grown in garden plots in southern and northern Ontario, and analysis of the collected data is almost complete. Cultivation trials examining differential growth of triazine-resistant and triazine-susceptible biotypes of *Senecio vulgaris* were completed and the data analyzed. Preliminary

competition experiments were conducted on atrazine-resistant and -susceptible biotypes of lamb's-quarters and late-flowering goosefoot, *Chenopodium strictum* Roth. Electrophoretic studies were initiated to assess population variation in lamb's-quarters. Biosystematic studies were completed on 15 populations of plantain, *Plantago major* L., collected from different habitats along an 800 km transect in

Ontario. Results indicated the presence of prostrate growth forms in habitats subjected to intensive mowing.

*Water hemlock.* A cytotaxonomic study of members of the water hemlock genus *Cicuta* was submitted for publication. It contains a key to known species, and taxonomic and other biological information is correlated with somatic chromosome karyotypes.

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## Ottawa, Ontario

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## INTRODUCTION

The activities of the Chemistry and Biology Research Institute are integrated into multidisciplinary, mission-oriented programs that have regional responsibility for research in basic and applied sciences related to agriculture. The activities are conducted under eight main programs including a new separate virus and mycoplasma program.

Research is concerned with interrelationships between microorganisms, viruses, soils, and plants. The research programs place particular emphasis on the mineralogy, biology, and chemistry of soils; frost hardiness; nitrogen fixation in legume crops; plant viruses and mycoplasma; environmental chemistry including organic toxins, trace elements, and pesticides; and fusarium/spot blotch disease. New or improved analytical methods for the determination of various constituents in agricultural materials are developed.

Services include mineralogical analyses by means of X-ray diffraction, electron microscope facilities, and analytical chemistry services. The facilities of the Electron Microscope Centre were used by various establishments within the Research Branch, universities, and outside agencies. The Analytical Chemistry Services provided a wide range of chemical analyses and structural information on extracts from agricultural and food products by means of advanced analytical instrumentation such as gas chromatography-mass spectrometry. Special technical assistance was given to the *N*-nitrosamine monitoring program of the Health of Animals Branch and PCBs analyses in Canadian poultry.

Highlights of the 1979 research program include evidence of biodegradability of most of the "unknown" soil nitrogen and the discovery that up to 25% of this nitrogen may occur in nucleic acid bases; chemical identification of bound pesticide residues; development of techniques for characterization of nitrogen-fixing bacterial strains and selection of plants for maximal nitrogenase activity; the establishment of mechanisms of resistance to and injury of plant cells by frost hardiness; and the discovery of peach X-disease transmission by certain leafhoppers. A "Bulletin" describing details of Analytical Chemistry Services in the Institute was published and widely distributed across the country.

There were some organizational changes in the Institute. The Director, Dr. Saha, assumed new duties in May as leader of the task force on managerial accountability and in November as Acting Director General of the Central Region. Dr. W. Baier, of the Land Resource Research Institute, was appointed Acting Director of CBRI in May 1979. Dr. Khan became Assistant Director in November 1979.

The Institute is missing the dedicated service of Mr. Allan Van Dusen, who died in August 1979.

This report summarizes only the highlights of our achievements in 1979. Reprints of the research publications and copies of this report are available from the Chemistry and Biology Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Wolfgang Baier  
Acting Director

## PLANT PATHOLOGY

### Fusarium

Certain thiol reagents promote earlier lysis of the cells of *Fusarium sulphureum* and enhance the cellular response to lower concentrations of the fungicide benomyl. The cell walls of young and mature conidia were shown to be drastically different from each other and from normal hyphal walls. These marked differences are reflected in the stability of the wall to chemical treatments. The

stability of the mature conidial wall may confer longevity to the cells.

Chlamydo spores of *F. sulphureum* were most resistant to heating in comparison to macroconidia and thiol-induced spores. However, the macroconidia were most resistant to desiccation and freeze-thaw stress. The thiol-induced spores were most susceptible to all three types of stress. These results indicate that macroconidia must also be considered as survival spores.

Macroconidial lipids showed no change upon desiccation of these spores, but the triglycerides of the chlamydo spores decreased by 50% with a concomitant increase in free fatty acids. All of the free water in chlamydo spores and macroconidia could be removed by desiccation without impairing spore viability.

The effects of the metabolic inhibitors clofibrate, SKF525A, AY9944, and Dimilin on the pathogenic wheat fungus *F. culmorum* were examined in relation to growth, oxygen uptake, and conidia germination. Clofibrate and AY9944 reduced sterol production by 88% and 72%, respectively, in liquid cultures. At 10  $\mu$ M concentration clofibrate, AY9944, SKF525A, and Dimilin reduced conidia germination 75%, 30%, 40%, and 40%, respectively. Their effects, except for clofibrate, on growth and oxygen uptake were insignificant. Clofibrate, however, inhibited growth 71% and simultaneously stimulated oxygen uptake 123%. The extraordinary effect of clofibrate on oxygen uptake by the conidia of *F. culmorum* is particularly interesting as it indicates a significant effect other than sterol inhibition. The other sterol-inhibiting agents SKF525A and AY9944 at the same molar concentration had no significant effect on oxygen uptake. The relatively high oxygen-uptake activity of cultures grown at 15°C coincides with the rather unusual membrane and lipid metabolic activities observed previously in *F. oxysporum* grown at the same temperature.

The inhibitors were not as effective on growth in agar cultures even at higher concentrations although the relative pattern of inhibition between the agents remained the same both for growth and sterol inhibition. Dimilin, an inhibitor of chitin synthesis, which has been used as an insecticide, demonstrated little effect on the growth of the fungus which also synthesizes chitin.

Although neither the prime site of activity nor the mechanism of action of clofibrate is clearly understood, the data obtained suggest its potential in the control of microbial plant diseases. The treatments of seeds with clofibrate to control root diseases in wheat seedlings is being examined.

### Spot blotch disease

A nonspecific sporeling adhesion factor which is responsible for the first and initial phase of host-parasite contact was obtained from *Cochliobolus sativus*. The substance

appears to be a positively charged polymer of galactosamine and is produced rapidly and in some isolates in relatively large amounts in liquid culture. Attempts are being made to stabilize and examine biologically the labile host-selective toxins of this pathogen.

### Rumen microbiology

Amino acid excretion by the rumen anaerobe *Eubacterium ruminantium* was followed in the presence of the valine antimetabolite  $\alpha$ -aminobutyric acid. Valine biosynthesis as an excretion was not subject to the normal regulatory mechanisms. Furthermore, the concomitant stimulation of isoleucine excretion indicated the importance of alternate sources of the  $\alpha$ -keto precursor of this amino acid (other than threonine deamination) in the anaerobic environment.

## VIRUS AND MYCOPLASMA

### Peach X-disease

Alternative hosts of the disease that may serve as reservoirs of the pathogen in nature and the herbaceous hosts that can be used as sources for purification of the mycoplasma are being determined. The disease was transmitted from infected chokecherry, collected in the Harrow area, to peach seedlings by the leafhopper *Scaphytopius acutus*. Also, transmission was achieved through another leafhopper, *Paraphlepsius irroratus*, from the same chokecherry source to celery, ladino and red clover, ragweed, broadbean, and chrysanthemum—the last four being new host records for the disease. An abundance of mycoplasma in tissues of all hosts to which the disease was transmitted was detected by electron microscopy. A technique for successful laboratory rearing of *P. irroratus* was developed. Diseased chokecherry, dogwood, and milkweed plants were collected in the Ottawa area and X-disease was transmitted from chokecherry to peach seedlings by bark grafting. Mycoplasma cells were detected in diseased peach seedlings.

Analysis of different parts of peach trees that were injected at Harrow with oxytetracycline, an antibiotic that provides remission of the disease, showed that residual antibiotic activity varied with the dosage injected, peach variety, time after injection, and individual peach trees.

## Forage legume diseases

Studies on a number of isolates of viruses from red clover fields showed that a virus, probably a strain of pea streak, is most prevalent in eastern Ontario. Cryopreservation studies revealed that clover phyllody and clover yellow edge mycoplasma could be preserved in their leafhopper vectors for at least 2 and 1.25 yr, respectively, at  $-64^{\circ}\text{C}$ .

## Barley yellow dwarf virus

In studies on annual variation of virus strain spectrum in eastern Ontario and western Quebec, the vector nonspecific, the corn aphid-specific, and the English grain aphid-specific strains were prevalent in oat and barley crops in 1979. The greenbug-specific strain was not found and the cherry-oat aphid-specific strain prevalent in 1977 was insignificant in 1978 and again this year. The strains of the nonspecific type have been common every year but the spectrum of vector-specific strains is quite variable from year to year. The cereal root aphid, a new vector recognized in 1978, was found to have a wide host range in cereals and grasses but did not appear to overwinter in Ontario.

## ENVIRONMENTAL CHEMISTRY

### Inorganic chemistry

*Silicon in animal blood plasma/serum.* A rapid, interference-free, filtration-light absorption spectrometric method was assessed and applied to the determination of Si in animal blood plasma/serum. The method gave analytical results more conveniently and precisely than conventional sample treatment by digestion/fusion, and a much reduced, reproducible reagent blank. Levels of Si found in bovine and ovine blood plasma and sera were typically near  $1\ \mu\text{g}/\text{mL}$ , with procedural reagent blanks consistently near  $0.1\ \mu\text{g}$  per determination. The method was applied to the measurement of silicon in plasma of lambs and ewes to evaluate the effects of environment, diet, and age on silicon concentrations.

### Organic chemistry

*Ergot alkaloids.* Chemical analyses of Canadian rye ergot have shown that there can be significant variations in the alkaloid content and composition of individual sclerotia. Up to 40-fold differences in total alkaloid content have been observed even from within

the same field. There are some regional differences in alkaloid content and composition; levels tend to be lower in Prince Edward Island, and among the dozen or so alkaloids present, ergotamine is the predominant one in the Maritimes, whereas in central Canada and on the prairies it is ergocristine. The composition of western Canadian wheat ergot appears to be similar to that of rye from the same region.

In a collaborative study concerning the toxic effects of ergotamine in poultry, preliminary results show that the alkaloid in feed has significant dose-related effects. Ergotamine caused reduced feed intake and weight gain, necrosis of skin and toes, and death.

*Pheromones and attractants.* Three acids, hexanoic, octanoic, and (*E*)oct-2-enoic, were identified in royal jelly volatiles, honey bee worker mandibular gland extract, and mated queen head extract. An attractive fraction was separated from an extract of queen honey bee heads by column chromatography. The activity was found to survive distillation but was lost when other techniques such as GC, HPLC, TLC, and hydrogenation were supplied. The volatile acids produced by the American foulbrood organism when grown on a culture medium have been studied and compared to those found in the brood from an infected hive. Nine acids were identified in the free acid fraction and ten in the saponified fraction from the culture. Eight of these acids were also found in the brood from infected hives, as well as two others which were not found in the culture. A fraction attractive to honey bees, isolated by column chromatography from a pollen extract, was further separated by HPLC. A mass spectrum of one of the components indicated a molecular weight of 533 and an infrared spectrum showed peaks indicative of an ester group and *trans*-double bonds.

*N-Nitrosamine in bacon.* A study was initiated to determine the botulinal inhibition of some fatty acylamino acids in combination with low levels of nitrite in bacon. Lauryl-methionine, applied to typticase soy agar and reinforced clostridial agar seeded with various microorganisms, significantly inhibited growth of *Bacillus subtilis*, *Bacillus cereus*, *Micrococcus luteus*, *Clostridium botulinum* (A and B), and *Clostridium sporogenes*, and somewhat inhibited growth of *Streptococcus zymogenes* and *Staphylococcus aureus*. Ground bacon inoculated with *Clostridium*

*sporogenes* showed that increasing amounts of laurylmethionine (0–30 mg/g) reduced the counts from  $2.7 \times 10^8$  to  $< 1.0 \times 10^3$  in fat bacon and from  $1.7 \times 10^7$  to  $< 1.0 \times 10^2$  in lean bacon.

## Pesticides

*Pesticides in organic soils.* Bound (unextractable) radiolabeled residues were formed when an organic soil treated with  $^{14}\text{C}$ -ring-labeled prometryn was incubated aerobically. A high-temperature distillation technique was developed for determining and chemically identifying the bound residues. A steady decrease of extractable  $^{14}\text{C}$  residues was accompanied by a corresponding increase of bound  $^{14}\text{C}$  residues over a 150 day incubation period. Similarly, a decrease of extractable prometryn residues over a 345 day period in the field-treated soil was accompanied by an increase of bound residues. A considerable portion of the bound residues was identified as prometryn. Data demonstrate that special attention should also be given to bound residues in assessing the persistence or disappearance of pesticides in the organic soil.

*Pesticides in mineral soils.* The  $K_{ow}$  (partition coefficient) values determined for fensulfothion, its sulfoxide, phorate, fonofos, and isazophos determined by gas chromatographic method were 230, 375, 6113, 8637, and 1864, respectively. Adsorption studies with fensulfothion showed that uptake of the pesticide by soil from water was very rapid. The half-life of fensulfothion in an iron-rich loam soil was found to be 45 days.

*Pesticides in plants and food crops.* Absorption of glyphosate and *N*-nitrosoglyphosate from soil treated with high rates of these compounds and their translocation in oat plants were observed in a greenhouse experiment. *N*-Nitrosoglyphosate moved more readily into the root and subsequently into the shoot of oat plants than glyphosate. Formation of *N*-nitrosoglyphosate in soil and its uptake by plants under normal field conditions is not expected.

The uptake of fensulfothion by rutabagas and carrots was determined using microfield plots treated with the equivalent of 4 and 8 kg/ha. Residue levels in rutabagas were 1.1 ppm in the roots, 0.6 ppm in the peel, and 0.1 ppm in the pulp for 4 kg/ha and 10.8, 2.1, and 1.5 ppm, respectively, for 8 kg/ha. In carrots, the levels were higher after both treatments, at 30.6 ppm in peel and 12.0 ppm in pulp for 4

kg/ha and 52.2 and 11.0 ppm, respectively, for 8 kg/ha. The ratio of sulfoxide/sulfone, which ranged from 0.3 to 1.2 in rutabagas and from 2.4 to 7.0 in carrots, suggested the presence of oxidative system in rutabagas.

A new metabolite of isazophos was isolated from the leaves of rye grass grown in treated soil. It was characterized as the dechloro derivative by GC/MS.

*Pesticides in farm animals.* The soluble fraction (105 000  $\times$  g) from goose, pig, and sheep liver-homogenates was found to contain an enzyme which metabolized a mixture of atrazine and simazine during in vitro incubation by a combination of hydrolysis and partial *N*-dealkylation. Complete dealkylation was not observed as evidenced by the removal of only one alkyl group, but not both, from the compounds containing chlorine or hydroxyl groups attached to the triazine ring.

## SOIL CHEMISTRY AND BIOLOGY

### Soil chemistry and mineralogy

*Uptake of cadmium by lettuce.* Experiments on the uptake of Cd by lettuce showed that there were significant differences in the uptake and accumulation of Cd in lettuce depending on whether Cd was added as inorganic salt or in sewage sludges. The average plant Cd concentration was about five times greater with inorganic treatments (28.09  $\mu\text{g/g}$ ) than with sludge treatments (5.65  $\mu\text{g/g}$ ). Results obtained from inorganic Cd amended treatments reported in the literature may not be reliable in the development of guidelines for land disposal of sewage sludges.

*Soil chemical characteristics as influenced by  $\text{SO}_4$  ions.* Investigations on the equilibration of  $\text{CaSO}_4$  solutions with some Canadian acid soils containing amorphous oxides showed that CEC of these soils increased after equilibration with  $\text{SO}_4$  solutions.

*Soil phosphate.* Two aspects of soil phosphate are of general importance to agriculture. One is the immediate availability of phosphate to growing crops, and the other is the long-range reserve of phosphate in agricultural soils.

Because it is assumed that bioavailability depends on the amounts and chemical species of phosphate in solution, an investigation was started on the chemical species in aluminum

orthophosphate solutions. The first studies are being done with aluminum phosphates, because of the importance of aluminum in the chemistry of high-rainfall Eastern soils. Since metastable and quasiequilibrium aluminum phosphate solution species are expected under field conditions, an acid-base titration method is being used.

*Effect of soil organic matter on the crystallization of aluminum hydroxides.* The presence of fulvic acid, a water-soluble soil organic matter fraction, at low concentrations delayed, but at high concentration inhibited the crystallization of aluminum hydroxides. At low fulvic acid concentrations, the crystallization of pseudoboehmite, an aluminum oxyhydroxide, over gibbsite was favored. Our data explain the absence of substantial concentrations of crystalline aluminum hydroxides in organic-matter-rich soils developed under cool temperate climates, although total aluminum concentrations in these soils are relatively high.

*Microbial formation of basic ferric sulfates in the laboratory and in soils.* These minerals, e.g.  $\text{Fe}_3(\text{SO}_4)_2(\text{OH})_6$ , are typically found in acid sulfate soils and are produced by microbial oxidation (by *Thiobacillus ferrooxidans*) of ferrous iron containing minerals, such as pyrite ( $\text{FeS}_2$ ). This reaction also produces  $\text{H}_2\text{SO}_4$  which causes the strongly acid and corrosive conditions. Acid sulfate soils were identified and analyzed for the occurrence and nature of basic ferric sulfates. It was found that in coastal areas of Eastern Canada potassium basic ferric sulfates were dominant in soils formed on tidal marine sediments, whereas in inland areas of Western Canada sodium basic ferric sulfates were dominant in soils developed on marine shales.

*Characterization and quantification of inorganic soil components.* Poorly crystalline components occur to some extent in all soils and have a dominant influence on the behavior of some soils. Research into the nature of these components and their effect on properties of some British Columbia soils showed that they contained imogolite, a fibrous aluminosilicate, hitherto not identified in Canadian soils. Although the chemical composition and micromorphology of these components were different from volcanic ash derived allophane, their effect on soil properties was similar. For example, soil surface

charge was strongly pH dependent and high soil plasticity was lost during drying.

An exceptionally pure illite from Eldorado, Sask., was mineralogically described in detail. In many respects, the illite represents 1 nm minerals, so-called clay micas, in soils and sediments more closely than do muscovites that have been used previously as standards in X-ray procedures for the quantification of minerals in soils and it could serve as standard mineral for the analysis of clay micas in soils and sediments.

*Chemical and clay mineralogical properties of ortstein soils from the Maritime Provinces.* Minerals in soils of Nova Scotia sites showed marked differences and weathering rates between well and poorly drained soils. Many of the B horizon clays appeared amorphous to X-rays. However, treatment with NaOH greatly increased diffraction maxima. SEM demonstrated improved particle orientation.

*Identification of members of the jarosite group of minerals by application of Vegard's Law to cell parameters.* Certain X-ray diffraction peaks were related to ionic radii, which proved valuable where various jarosites were formed in heterogeneous soil mineral assemblages.

*Methodology advances in soil mineral analysis.* Guinier X-ray diffraction and infrared analyses made possible more sensitive identifications of lepidocrocite and feldspar minerals in soils.

*Mineralogical analysis service.* This unit provided X-ray diffraction analyses for 1300 samples by one-, two-, or three-dimensional patterns of internal atomic structures. Sixty-five DTA and TGA and 300 infrared analyses were recorded. Computer programs were developed for qualitative and quantitative analyses.

### **Soil organic matter and organic soils**

*"Unknown" nitrogen in soils.* Purines and pyrimidines were found to account for up to 25% of the "unknown" nitrogen in a variety of soils and humic materials. Biodegradation experiments with soil microbes showed that nucleic acid bases adsorbed on clays were ready sources of available nitrogen, but when the bases were adsorbed on iron and aluminum oxides, little nitrogen was released.

*Different forms of soil nitrogen.* Improved methods were developed for rapid measurements of ammonia and nitrate levels in soils, using specific-ion electrodes, and for determination of nitrogen isotope ratios by optical emission spectroscopy. The electrode methods were used to monitor ammonia and nitrate levels in a field experiment. The distribution of nitrogen in organic soils was determined, and found to be unaffected by the level of microbial and enzymic activity.

*Carbohydrates in soils.* A study was undertaken on the organic matter and carbohydrate distribution in an Orthic Humic Gleysol. Gas-liquid chromatography was used for the determination and quantification of the neutral sugars and amino sugars in soil fractions of different particle sizes, including the water-soluble fraction and plant residues. The ratios of neutral carbohydrates to organic matter as well as the distribution of monomers varied among individual fractions. A correlation was found between the amino sugar and nitrogen contents in each fraction, with the exception of the water-soluble fraction and the clay particles. Results of this study support the view that polysaccharides in soils, with the exception of the obvious plant remains, are of microbial origin.

*Chemistry of humic and fulvic acid.* New information was obtained on shapes, sizes, and degrees of association and dissociation of humic and fulvic acid particles under different experimental conditions. Under conditions similar to those prevailing in soils, humic materials behaved like flexible, linear colloids.

To discover whether humic substances could serve as indicators of soil and water pollution, analytical characteristics were determined of humic and fulvic acids extracted from unpolluted and polluted soils and sediments. Unusually high contents of sulfur, nitrogen, carboxylate groups, secondary noncyclic amides, and of copper, chromium, zinc, and mercury were found to be valid indexes of environmental pollution.

*Chemotaxonomy of organic soils.* The utility of monosaccharide analyses as chemotaxonomic aids for organic soils was demonstrated further by the results obtained from 19 horizons in three Manitoba soil profiles. The distribution of the monosaccharides was found to be related to several characteristic physical, chemical, and morphological properties. The Manitoba soils were different from

other soils examined thus far in that appreciable amounts of deoxy-sugars were found.

*Pesticide studies.* While the humus content of four soils appeared to modify the effectiveness of Dyfonate and Duradan, both insecticides did not hamper soil microorganisms in these soils.

*Subsidence.* The measurement of a single enzyme (acid phosphatase) activity was found to be a promising method for assessing the potential biodegradability of virgin organic soils. Earlier evidence that Cu (<100 kg/ha) continuously inactivates certain degradative enzymes in organic soils and thus mitigates decomposition and subsidence of these soils was corroborated by studies of as many as 15 such enzymes in >50 soils. Attempts at testing the efficacy, safety, and economy of applying Cu as a practical method for mitigating subsidence showed that Cu at even >300 kg/ha enriched neither crops nor groundwater adversely with Cu, nor did it significantly curtail certain desirable and mainly intracellular soil microbial processes.

## SYMBIOTIC NITROGEN FIXATION

### Characterization of *Rhizobium meliloti* strains

Antisera against 24 *R. meliloti* strains were prepared and homologous titers were determined. Serological analysis through immunodiffusion allowed the 24 strains to be categorized in distinct groups. A collection of 15 different bacteriophages from local soils was used to classify 72 strains of *R. meliloti* into 30 distinct groups. A system of reference profiles characterizing the natural resistance of *R. meliloti* strains to 36 antibiotics was developed and used to classify 40 strains into major groups with subgroups. This method complements the phage typing system. Together, the three characterization criteria will allow identification of the strains to be used in competition experiments and to determine the survival ability of improved inoculants under various soil conditions.

### Improvement of host and symbiont

Collaboration between plant physiologists and microbiologists resulted in further refinement of screening systems for identification of individual alfalfa plants having superior performance and nitrogenase activity in combination with various *Rhizobium* isolates.

Over 10 000 alfalfa plants were screened. Clones of promising plants will be maintained for use in an alfalfa breeding program. Local *Rhizobium* isolates and strains from the extensive world collection maintained in CBRI have been compared for effectiveness on one cultivar. This work will continue and include determination of plant yields under standardized conditions. The whole question of plant breeding criteria for optimal nitrogen fixation has been identified as a problem area requiring new approaches, and is of worldwide concern which can only be resolved by more experimental data.

### **Rhizobium genetics**

Three mutagen-produced auxotrophic mutants of *R. meliloti* were determined to be stable though producing defective (nonnitrogen-reducing) nodules. Putative insertion mutants of *R. meliloti* were produced with phage  $\mu$  utilizing *E. coli* as an intermediate carrier. Of 50 conjugants tested, two produced defective nodules. The nature of these mutants is being determined. Work on introduction of genes coding for a soluble hydrogenase (Hup) from *Alcaligenes eutropus* into *R. meliloti* began with the isolation of a large plasmid from *A. eutropus*. *A. eutropus* cells from which the plasmid had been eliminated failed to grow autotrophically indicating the absence of the Hup gene for the uptake hydrogenase. This project requires considerable development, but has the potential of increasing alfalfa yields through recycling of  $H_2$  formed as a by-product of nitrogenase function in nodules.

### **Optimization of plant growth on symbiotically fixed nitrogen**

Experimental determination of specific growth rates of alfalfa demonstrated that the early growth advantages of plants grown on optimal levels of  $NO_3^-$  was altered after 24 days apparently due to switchover to  $NH_4^+$  utilization. Attempts to induce earlier transition to "symbiotic growth" have been successful and could lead to cultural recommendations of agronomic importance. This work, aimed ultimately at breeding alfalfa cultivars better adapted to early growth on symbiotically fixed nitrogen, represents a major thrust of the program.

Cultural conditions permitting assessment of the optimal concentrations of calcium ion

producing highest symbiotic nitrogenase specific activities were determined. The effect of this cation on nodule number and weight and symbiotic effectiveness are being evaluated. Preliminary results indicate that higher levels of calcium are required than previously expected.

### **Energy utilization in symbiotic nitrogen fixation**

A method has been developed for comparing photosynthetic ability of individual alfalfa plants. Application of this method will complement breeding experiments aimed at enhancing growth rates on symbiotically fixed nitrogen. We are investigating the mechanism by which the free energy of hydrolysis of ATP is utilized in nitrogen fixation. Further information on this complex process will help to explain the large amounts of ATP required to drive the nitrogenase system. At the same time, the genetic engineering approaches are aimed at increasing the available supply of energy for nitrogen fixation through recycling hydrogen gas or through more efficient coupling of bacteroid respiration to ATP synthesis. The overall nodular efficiency for energy utilization in the nitrogen fixation process will be proposed as a selection criterion for plant breeding.

## **WINTERHARDINESS**

### **Environmental studies**

Studies on relation of environmental conditions in fall and winter such as low temperatures, ice encasement, and flooding to survival of winter cereals have continued with emphasis on field monitoring of winter survival. Sixty winter wheat and triticale lines from Guelph, Harrow, and Ottawa were evaluated in the field at Ottawa for winter survival under natural and ice-encased conditions. Fall emergence, survival in spring, and grain yield were determined. Considerable separation of entries useful for selection purposes occurred in the stressed plots, whereas little or no damage was sustained in the natural plots. Fall emergence, spring survival, and grain yields of eight cultivars at five sites on eastern Ontario farms were also determined. Survival was generally good, but at one site it was reduced in the presence of an ice cover. Two hundred and eighty-eight lines from a cross between Fredrick winter wheat and a winter triticale were acclimated and cold stressed



and the hardiest survivors propagated. Several lines harder than Fredrick emerged. A study was made of the relationship between severity of flooding and subsequent cold hardening and icing tolerance. Short periods of flooding (2 wk) decrease cold hardiness, but increase resistance of wheat plants to ice encasement injury. Flooding of barley, on the other hand, decreases its resistance to injury by ice encasement. Longer periods of flooding increase susceptibility to ice. Preflooded plants show higher levels of anaerobic respiration in ice encasement than nonflooded plants.

Efforts to determine cellular sites of injury in ice encasement by electron microscopic (EM) examination of sections from cold-hardened wheats show little of the characteristic contraction of cells and formation of endoplasmic reticulum membrane whorls observed in whole plants encased in ice. Studies on metabolic effects of ice encasement and freezing suggest that these stresses promote the alternate cyanide insensitive electron transport pathway in mitochondria of hardy wheat plants.

### **Membrane properties in plant hardiness**

Cooperative studies initiated with Drs. J. Raison, T. McMurchie, and L. Wright, CSIRO, Australia, suggest that the properties of membrane-bound ATPases in wheat are different from those in other plants, thereby accounting for previously reported difficulties in establishing reliable plasma membrane markers in wheat. In spin-label investigations using free protoplasts, concanavilin A conjugated to ferritin was tried as a plasma membrane label to ascertain ultrastructural damage incurred during freezing, but binding was found to be too inconsistent for EM detection. Similar attempts to label with lanthanum ions to determine membrane injury showed these ions to be deleterious. Attempts at mass isolation, by use of enzymes, of single mesophyll cells from epicotyls of cold-hardened winter cereals have proved successful but thus far these cells have been maintained viable for only 4 days. Attempts at isolation of similar cells from unhardy plants have failed.

### **Desiccation studies with winter rye seedlings**

Earlier studies on induction of cold hardiness and drought resistance in winter rye

seedlings by desiccation stress at room temperature in the dark have been extended by the finding that the major part of the process of induction is accomplished in the first days of imposition of the desiccation stress. Thus, it would appear that much of the chemical and physiological process associated with cold hardening and development of drought resistance in these seedlings is completed soon after exposure to the desiccation stress. While the cold hardiness that is achieved under the desiccation stresses is not as great as in normal cold hardening of these seedlings, the drought resistance that has been found to develop is extreme so that water content of the seedlings can be reduced to 4% and still retain a capacity to recover completely on subsequent addition of water. So little water is retained in these seedlings after desiccation that they can be cooled slowly to liquid nitrogen temperatures without suffering injury, thereby affording a possible alternative to seeds as material for long-term cryopreservation of germ plasm.

## **ANALYTICAL CHEMISTRY SERVICES**

The Analytical Chemistry Services continued to provide Branch establishments with a comprehensive service in analyzing materials as part of research program. Two analytical methods, concerning microdetermination of total sulfur and inorganic sulfate in biological material and the determination of molybdenum in plant tissues and blood plasma, were developed and used for analyzing samples. In addition, two cooperative projects, concerning amino acid and glycosaminoglycan composition of epiphyseal cartilage of neonate and osteoporotic lamb, and the effect of manganese-deficit feeding to ewes, were completed. The section also provided special services and technical help in *N*-nitrosamine monitoring program; PCB analysis in chicken and turkey; and amino acid analysis for possible application of single column methodology developed for determining the myofibrillar, stroma, and nonmeat proteins in extended meat products.

The four subunits of the Analytical Chemistry Services completed more than 88 000 analyses. The Amino Acid Laboratory carried out 4103 protein hydrolysates and 340 physiological fluid samples analyses. The Instrumentation Centre used capillary column GC-MS

as a routine analytical technique for separation of some components in complex biological samples. The Centre produced 1664 spectra consisting of 163 NMR, 185 IR, and 1316 mass spectra. The Microanalytical Laboratory carried out 3475 organic elemental microanalyses. The Technical Service Unit performed 78 287 analyses for a wide variety of constituents. The Unit procured two new computer Datacom 400 terminals which improved the calculations, compilation, and storing of analytical data. The glassblowing service unit processed more than 130 orders for various Branch establishments.

From the standpoint of effectiveness, efficiency, and economy, the Analytical Chemistry Services proved to be extremely beneficial in the Research Branch. This is evidenced by the fact that excess of benefits over the cost of analyzing these samples was about \$1 200 000 (based on 1978-1979 rates).

A "Bulletin" describing details of Analytical Chemistry Services in the Institute was published and copies sent to scientists across the country.

## ELECTRON MICROSCOPE CENTRE

Sixty-seven professional and technical staff of eight Central Region institutes, five research stations, three universities, and six

outside agencies made use of the personnel and facilities of the Centre. The Postal Service aided investigations on the effects of herbicides on apple roots (St-Jean), "gray tobacco" (L'Assomption), and virus infections of plants (Harrow).

The Centre contributed to research publications in a number of diverse agricultural disciplines, including biosystematics, microbiology, plant pathology, and plant, animal, soil, and food science. Particulars of these publications appear under the listings of the institutes and stations in this Report.

The developmental research within the Centre on the freeze-fracture, thaw fix technique was extended to a study of the nucleoid of *Escherichia coli*. Conditions were established to control the unfolding of the nuclear complex in this organism following fracture. Optimum freeze-fracture conditions and the use of various cryoprotectants were investigated for tissue slices of *Vicia faba* roots and alfalfa nodules. Reliable methods were developed for replicating fracture faces for high resolution studies.

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## INTRODUCTION

In April 1979 the Ottawa Services Section, which provided technical services for scientific equipment on the Central Experimental Farm campus, was amalgamated with the Institute. This brought together all the operation resources needed for the development, construction, and servicing of scientific equipment. During the year the various workshops were combined into consolidated units to make the most effective use of facilities and personnel. The Institute focuses on five major activities:

- Energy in the food and agricultural system—To develop and apply existing and new technology to contribute to the National Energy Strategy for Canada's energy self-reliance through conservation of energy and the use of alternative energy sources (wind, solar, biomass) to reduce the dependence of the agricultural and food system on fossil fuels on an economic basis.

- Engineering and statistical research and development (R & D) support—In support of and in collaboration with all commodity goals, to support the Branch and Departmental research and development program through services in statistical design, analysis, and interpretation; and in engineering technology for new instruments, apparatus, and equipment to improve the efficiency and accuracy of research and assist in new areas of research. To modify equipment essential to research operations and to provide a maintenance and repair service for scientific equipment.

- Machinery and structures technology—To support Branch and Departmental programs on farm machinery and structures by the provision, development, and assessment of new and existing technology. To promote engineering R & D in industry through a contracting out program and to develop national farm building standards through the Canada Plan Service.

- Food-process engineering—In collaboration with and support of several Branch establishments, to develop improved technology or equipment for the processing of selected plant and animal products and establish the physical characteristics of these materials that govern processing.

- Technical and scientific information—On a continuing basis to maintain a national information resource on agricultural engineering and disseminate information from this source and from the Institute's R & D results.

Contracting out of R & D is now a major effort which supplements the "in house" resources applied to energy and to machinery and structures technology.

Emphasis is at present being placed on coordinating computer software in order to make statistical programs available to the Department via the new computing network AgNet.

The results of the diverse program are indicated in the report. Further information is available upon request from the Engineering and Statistical Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Peter W. Voisey  
Director

## MECHANIZATION AND SYSTEMS

### Equipment and systems analysis

Field machines were designed for various needs, usually in cooperation with research stations. The principles utilized in the design of a bed seeder for baby carrots were extended to develop a machine for various vegetables, which is now commercially available. A leaf-removing device for a broccoli harvester was successfully developed. A stalk

cutter for Burley tobacco is now being manufactured; the device shows considerable advantage over hand cutting. The row-crop injector shank also successfully injected manure into sod. Modifications were made to the peatland tractor, and testing resumed in Newfoundland, demonstrating a standard for prime movers in peatland production systems.

Assessments and analyses of some existing mechanization were made. A precision vegetable planter was evaluated for planting lettuce, cabbage, and onions. Two hay towers

brought into use at the Melfort Research Station are now part of their routine operation. An Australian-designed grain cleaner, utilizing an eccentric drive principle, was constructed; preliminary tests showed possible high throughputs, but problems were demonstrated with some types of grain. Design plans adapting a seeder previously developed for horticultural crops to seed forage plots were supplied to a manufacturer, and two prototypes were built and sold. Spin-off applications to tree nurseries are possible.

The systems analysis work was highlighted by a successful workshop with 55 participants, after which a proceedings was published. A catalog of agricultural engineering computer programs was assembled and distributed. Computer models were set up and tested to simulate crop growth, beef animal growth, field drying of crops, and dryland grain production. A software package was developed to present data in three-dimension format.

### **Contract research and development**

Management of the agricultural engineering research and development (AERD) contracting-out program for the Branch continued. Summaries of the results of 30 completed projects were published. Most proposals previously rated acceptable were implemented, and 160 new proposals for 1980-1981 were reviewed. In addition, 32 unsolicited proposals were evaluated and 10 accepted for implementation. In mechanization and buildings, 21 contracts were completed, 6 are continuing, and 29 new projects were implemented. In energy, 10 contracts were completed, 8 projects are continuing, and 20 new ones were started.

Work accomplished under the contracts is reported individually by the Branch establishments assigned the scientific responsibility for each project.

The Mechanization and Systems Section supervised six energy contracts and eight mechanization contracts. A review of the potential for using wind energy for agriculture was completed, identifying wind regimes, possible agricultural applications, and suitable economic thresholds, along with recommendations for further work. The Martin track was developed to provide suitable flotation for combines working in wet soil conditions. An improved soil leveler was built, production drawings were prepared, and a

publication for farmers was prepared by the Quebec Ministry of Agriculture. A bale wagon and elevator system to handle randomly placed bales was developed, providing complete mechanization of a bale-throwser-based system. Evaluation of a tomato harvester, developed under a previous contract, contributed to the sale of 12 machines, with 30 to be manufactured for next season. A spinach harvester was developed, and three units were sold for delivery in 1980. Silage distributor problems were investigated and documented. In one case, the silage blower did not purge toxic gases, contrary to existing recommended practice, and a warning letter was issued. A rotary bean puller investigated under a previous contract is now being manufactured and gives improved performance. A concept has been developed for a round bale processor to improve hay feeding systems and prototypes are being tested.

## **RESEARCH SERVICE**

### **Mechanical and plot equipment**

Equipment developed to mechanize field experiments included: equipment to measure root and stalk strength of corn for breeding selections; a string seed spacer for precisely spaced planting of cereal breeding crops; a prototype nursery shrub lifter; metricated hog back fat measuring scales; modified oat dehulling machine to separate oats from hulls and debris; a skeletal measuring device for meat birds; a portable rain simulator for herbicide leaching and degrading; a metricated egg air cell gauge for studies of egg storage quality; and an improved lamina punch to take tobacco leaf samples.

### **Electronic instrumentation and data acquisition**

Electronic instruments developed to increase research in a variety of disciplines included: a prototype automatically controlled sheep digesta sampler, to improve the efficiency of trace mineral analysis in animal nutrient studies; a multisample rapeseed counter, modified to improve performance; an electronic muscle stimulator system, for inducing green muscle disease in turkeys; a prototype automatic feeding and weighing system, to determine feed conversion efficiency of individual animals; an adaptor for interfacing specialized equipment to a data processing network; and a potential wide-area

pest-warning system, using appropriately located commercial data acquisition equipment.

By contract, software for a HP 3052 data acquisition system was developed to interface with any PDP-11 computer. A prototype automatic feeding and weighing system for livestock was also completed by contract.

### **Electrooptical instrumentation and field spectroscopy**

Electrooptical instruments and experiments developed to measure spectral behavior of grain and horticultural crops and CO<sub>2</sub> release-uptake by plants included: lettuce maturity detection, which indicates that in the 1100-1200 nm spectral band the growth or maturity of the lettuce can be followed for the planning and marketing of lettuce; a bioluminescence spectrometer was modified to relate luminescence of any crop of its nutrient deficiency; a holographic technique developed to test young cereal crops demonstrated that it can be used to shorten the time to breed a specific variety; an oat fluorospectrometer which identifies six oat varieties was completed; an open path CO<sub>2</sub> analyzer was developed for airborne applications; the project on detection of oil, moisture, and protein in grain was terminated as the technology developed has been incorporated in commercial equipment.

### **Food processing, quality, and energy**

Food-processing and quality equipment development included: a tomato pulper to improve sample preparation for varietal research; a technique, for which trials were completed with NRC, for extraction of albumin and globulin using reverse osmosis; color grading of white beans with commercial colorimeters to measure differences in bean color; a technique reducing the energy needed for pasta drying by about 30%, using cyclical drying; using an electronic recording grinder for wheat which measures energy used in grinding to show that the speed reduction of the grinding head relates to grain hardness; a method to measure tomato juice viscosity to select varieties for juice production; an attachment to the Ottawa texture measuring system, for measuring texture of food in plastic tubes; and instrumentation to monitor the energy needed to pump liquid manure to remote lagoons.

A pilot plant study on anaerobic digestion of hog manure for energy production was completed, where methane for energy and microorganisms for feed protein supplements were recovered. A review of alcohol fuels from agricultural products was completed, where all aspects of alcohol production on farm scales are discussed.

Contract studies in the biomass energy area were completed, including the pyrolysis of agricultural biomass for farm operations. The study evaluated some of the parameters of temperature, residence time, and feedstock on the production of gases, liquids, and solids from the process.

## **STATISTICAL RESEARCH**

### **Programming and data processing**

The major project has been preparation of statistical software for the new computer network, AgNet. This has involved a survey of Research Branch requirements and the modification of existing library programs to begin to meet existing needs. Between 60 and 80% of the Branch's statistical software needs will be covered by the programs that will be available when AgNet starts up.

The library maintenance and enhancement functions, data analysis, and computer consulting services have continued. Reports for such projects as Ontario regional potato trials, bertha armyworm oviposition studies, and the Fredericton potato field book were prepared.

### **Natural resources**

A model to predict Canadian or world cereal production was developed for the Wheat Board. A major contribution was made to a soil classification and genesis project; the results disseminate information on background levels of many elements in soils throughout Canada and provide a benchmark for assessing the magnitude of soil contamination and for evaluating the effectiveness of countermeasures to pollution.

### **Production development (animals)**

Although magnesium-supplemented diets proved ineffective in treating hypomagnesia, a number of questions were raised about the diagnosis of this condition. A sampling procedure was devised to compare various methods of diagnosing paratuberculosis in cattle, and presently used methods were studied.

Experiments were designed to study fat synthesis and deposition in piglets. A survey of swine influenza established that there are high incidences of several strains in Canada, and modifications to current testing procedures were proposed to overcome their deficiencies in detecting antibodies to the strains now most prevalent in Canada. Information has been obtained about salt requirements of gilts during and shortly after pregnancy.

Several studies of eggshell quality and strength were designed and analyzed; they indicate that shell strength is affected by temperature and other environmental conditions. A chick assay for lysine in wheat has been developed.

The data from several experiments concerning artificial insemination of sheep indicate that reproductive performance is worse using frozen semen than it is with fresh semen, that the application of estradiol-17 $\beta$  is detrimental to reproductive performance, and that an 8 mo breeding cycle is feasible. Cement kiln dust supplements were shown not to improve lamb weight gains. The quantitative assessment of cross-reaction of virus strains in immunology was studied, and a method was provided to overcome a previously unsolved problem.

### **Production development (crops)**

Optimal tobacco plot size (minimum area with acceptable precision) was investigated, and recommendations were made.

Work in potatoes led to use of a new design for large numbers of test lines. A method of estimating optimal seeding rate for wheat was proposed. The barley register was maintained and updated.

An analysis of studies relating incidence of lesions in rats to dietary fatty acid levels was performed.

### **Production support**

Statistical support was provided in: bioassays of herbicides in different soils; studies of synergism; joint action of fumigants; and influences of sex and body weight on potency of grasshopper insecticides. Sequential trials and other design modifications were introduced to improve the power of experiments studying insect aggregation. A report was prepared recommending the rejection of a

method proposed to detect arsenic and selenium in foodstuffs. Investigation of reflectance characteristics of maturing lettuce led to a predictive model.

## **STRUCTURES AND ENVIRONMENT**

### **Canada Plan Service (CPS)**

The CPS Design Center, cooperating with Information Services of Agriculture Canada and the 10 provincial departments of agriculture, prepared and distributed 18 complete building plan sets along with 42 leaflets. Metrication of plans has progressed to the 60% level. Production of plans in imperial units has terminated. A major change has been a move toward component system design in lieu of numerous complete building plan sets, which will provide the provincial extension engineers and farmers with more flexible and useful information.

### **Research and development**

A field plot study to determine the effects of rate and time of manure application on corn yields and on nitrogen, phosphorus, and potassium losses in subsurface and surface runoff showed no improvement in corn yields with N above 224 kg/ha per year and excessive nutrient concentrations from winter-applied manure at all rates used.

An experimental tower silo foundation was evaluated by measuring settlements, frost heave, and footing ring distortion. The data for 2 yr were presented in a technical report; results showed that the silo moved 175 mm out-of-plumb during frost heave but resettled to 50 mm out-of-plumb.

Four different truss joint connection arrangements were load tested; one of these connection techniques reduces the number of nails required to assemble roof trusses by one-half.

### **Contracted-out research and development**

Staff were scientific authorities on 21 contracts dealing with solar applications, solar greenhouses, and conservation of energy in farm buildings, greenhouses, and crop drying. An in-wall system for short-term storage of solar heat shows good economic promise. Tests of one proposed collapsible blanket system for greenhouse heat conservation proved impractical.

A cement sandwich wall panel, developed and tested in one contract, was used to construct a barn, with favorable results.

### Engineering and drafting

Thorough structural reviews of 35 sets of building plans were carried out for the Department's fresh fruit and vegetable storage assistance program. In cooperation with Animal Research Institute, Public Works Canada, and consultants, planning was completed for a dairy feedlot for summer research operations at the Animal Research Institute site on the Greenbelt Farm. An action program was initiated by establishing an ad hoc committee to obtain a better knowledge of on-farm hazardous gases as related to human safety, and to develop gas detection and ventilation equipment for safe operation of tower silos and liquid manure tanks.

## TECHNICAL AND SCIENTIFIC INFORMATION

The Section continues to provide information to agricultural engineers, both by responding to specific inquiries and by publicizing projects being conducted by the Institute and publications resulting from past work. The Section's information collection continues to be updated, with increased emphasis on matters related to energy. A computerized information data base is employed as an aid in retrieving information and for preparation of custom bibliographies in response to requests for information. Over 2200 new references were added to the system. An investigation of methods for preparing manuscripts and other documents in the Institute was initiated, which resulted in the acquisition of a word-processing system to increase efficiency. Involvement in the metrication program of the construction and agricultural equipment sector resulted in development of nominal metric bulk densities of common seeds and a metric practice guide.

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# Food Research Institute

## Ottawa, Ontario

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E. LARMOND, B.Sc.	Assistant Director
D. J. DOBSON	Administrative Officer

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Dairy proteins  
Oilseed processing  
Dairy products  
Cereal lipids

### Departures

J. A. ELLIOTT, B.S.A., M.Sc., Ph.D.  
Retired 28 December 1979  
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Resigned 3 July 1979  
W. A. MCGUGAN, B.S.A., Ph.D.  
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Microbiology—dairy  
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## INTRODUCTION

The Food Research Institute (FRI) registered good progress toward all its goals in 1979, in spite of difficulties in staffing to replenish recent retirements and resignations and to respond to increased allocations of staff. At year's end two long-resident and valuable employees of the Institute retired: Dr. Jim Elliott from our microbiology laboratories and Dr. Wes McGugan from the flavor research program. A large group of people gathered at FRI and joined many others not present to wish them well and thank them for their contributions to Agriculture Canada and the field of food science and technology.

The Institute's organization was closely aligned to departmental objectives in 1978, and the programs and staff allocations have been reviewed and consolidated in 1979 to best respond to these. Strengthening of the Food Safety and Nutrition program continues as a high-priority goal, as does enhancement of technology transfer, technical service, and collaboration with the Canadian food industry. FRI continues to serve on all committees of the Canada Committee on Food, and looks to these as important contributors to the definition of long-term research and development needs in food science.

The research of the Institute is providing valuable information in many sectors of a broad field of interest, but important activities include licensing and commercial assessment of FRI rapeseed technology, demonstration of whey utilization as animal feed, new cereal processing technology, further understanding of mechanisms of extrusion cooking, whey protein denaturation, and processed meat production. In addition, the development of new food ingredients from a variety of agricultural products remains a strong program.

This year the Institute welcomed Dr. R. C. McKellar to the staff, where he will join our food quality program and commence research on dairy product microbiology. The Institute was also pleased to have Dave Dobson join us as Administrative Officer following the resignation of Jacques Joannis, who turned to farming as a long-term personal goal after many fine years with FRI and the Department.

This report covers only highlights of the total program. Enquiries regarding any aspect of the Institute program and for reprints of its publications are welcomed, and should be directed to the Food Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

John Holme  
Director

## FOOD PROCESSING

### Mechanisms of extrusion cooking

In order to adequately assess the results of the effects and interactions of process variables and wheat flour components on product viscosity curves, a versatile computer program has been developed in cooperation with the Engineering and Statistical Research Institute and the Land Resource Research Institute. With an appropriate interface, this program has been used with a plotter to generate three-dimensional color or black-and-white projections of viscosity as a function of temperature and extruder operating conditions. This development reduces data that are too complex to handle and presents the information in a visually effective manner,

enabling improved curve comparisons to be made.

Cereal flours have been processed using the novel split-barrel extruder under constant moisture and screw speed but under varying conditions of temperature and screw geometry. By splitting the barrel upon completion of each extrusion, zones within which the moist flour is transformed into other phase states have been identified and photographed. This enables these phase transitions to be related to operating conditions and to the functional characteristics of the product.

A method has been developed to measure the degree of cooking of any extruded cereal-based product. Presently there is no satisfactory or universally adopted method available. The new method takes advantage of the viscosity-temperature response of the starch

component and makes use of a previously reported development, the Ottawa starch viscometer. Total analysis time from sampling is approximately 20 min.

### Meat products

Various nonmeat proteins have been incorporated into wiener batters to determine their influence on yield and texture of products. Although yields were improved, effects of these proteins on product texture were much more variable and generally deleterious. An evaluation of various functional properties of nonmeat proteins as possible predictors of behavior in wieners revealed that only thermally induced viscosity increases were useful. Although some plant proteins behave better than others, no consistent relationships are evident and none behave as well as the control.

### Milk-coagulating enzymes

Chicken pepsin exhibits a greater rate and degree of proteolysis than calf rennet, resulting in a lower cheese yield. Proteolysis has also been shown to result in production of bitter off-flavors. For these reasons, chicken pepsin is not to be recommended as a replacement for calf rennet in Cheddar cheese manufacture.

### Gelation of milk proteins

The influence of various milk components, e.g. casein micelles, whey proteins, and minerals, upon the microstructure of acid-heat milk gels in the pH range of 4.6–6.3 was examined. Microstructures varied with the conditions used. The unusual corelike structures surrounding casein micelles (at pH 5.5) were observed only when casein micelles were heated in the presence of  $\beta$ -lactoglobulin and glocono- $\delta$ -lactone.

## FOOD QUALITY

### Carbohydrates

Studies on alginates were concluded. Although L-guluronic acid has been known as a constituent of alginates since 1955 no crystalline derivative of this acid was known. L-Guluronic acid was characterized, for the first time, both as a crystalline brucine and a crystalline sodium salt. The difference in  $[\alpha]_D$  values of the brucine salts of D-mannuronic and L-guluronic acids provided the basis

of a polarimetric procedure for determining the composition of alginates. Further improvements in the decarboxylation technique of Siddiqui and Morris were introduced to make it suitable for the optimal analysis of alginates. The isolation of sodium L-guluronate provided the necessary standard to determine the stability of L-guluronic acid under the hydrolytic and decarboxylation conditions. Finally a convenient procedure for producing gram quantities of L-guluronic and D-mannuronic acids was developed.

Synthesis of 4-O- $\beta$ -D-glucopyranosyl derivatives of vanillic and  $p$ -coumaric acids were performed for sensory evaluation tests, in view of the interest in the natural plant polyphenols as possible causes of the bitter or astringent character or both of seed- and leaf-protein meals.

### Amino acid methodology

One preparative and three accelerated analytical single-column chromatographic methods have been developed for determining all the unusual basic amino acids in proteins, physiological fluids, and a variety of tissues. This study extends and refines the work reported earlier and includes the complete separation, isolation, and automated determination of all methylated basic amino acids, the diastereoisomers of 5-hydroxylysine, desmosine, and isodesmosine and all stable cross-linking amino acids and related compounds derived from collagen and elastin. The accelerated methods are designed to be used with both conventional and fully automated amino acid analyzers and have the advantages that complete separation of all these components is possible in a single analysis and that the time required for a complete analysis has been reduced from 24 to 9 h. The sensitivity and speed of these methods have proven valuable for assessing the nutritive value, connective tissue content, and protein quality of animal protein supplements such as squid, fish, meat, and bone meals.

This approach has also been successfully applied to the assessment of the myofibrillar and connective tissue content of meats and several meat products. The most significant finding is that the myofibrillar and connective tissue contents of the meat blends analyzed are linearly related to the amounts of  $N^{\Gamma}$ -methylhistidine, 5-hydroxylysine, and stable cross-links present.

## Microstructure

*Cheddar cheese.* Based on a method developed earlier, Cheddar cheese made in Canada and the USA was surveyed for curd junction patterns. This survey covered Cheddar cheese made by all the different technological procedures used in North America. All the automated equipment used to produce Cheddar cheese elongated the curd granules ("cheddared" the curd) to a lesser or greater extent. Some equipment produced characteristic patterns. All the results are in the form of permanent records as dried cheese slabs (2 × 50 × 70 mm) and micrographs.

*Buttermilk.* Buttermilk made from sweet cream is difficult to distinguish from skim milk by chemical analytical methods. The knowledge of this difficulty may lead to adulteration of skim milk with buttermilk, particularly because buttermilk commands a lower price than skim milk. However, morphology of the pellets obtained by ultracentrifugation (80 000 × g for 2 h) of reconstituted skim milk and buttermilk, as examined by electron microscopy, differed considerably. In pure skim milk the pellet consisted exclusively of casein micelles, but in buttermilk there was a high concentration of fat globule membrane fragments and cellular debris in the pellet. On this basis, it was possible to detect as little as 5% of buttermilk blended into pure skim milk. Some commercial skim milk specimens, however, were found to contain membranous material; it is possible that such products already contained buttermilk. A morphological survey of skim milk specimens from various producers is being carried out.

*Freeze-fracturing.* A new electron microscopical method developed by Dr. G. H. Haggis and E. Bond of the Chemistry and Biology Research Institute for studies of animal and plant cells was adapted to milk products. This method consists of freeze-fracturing the specimen in a cryoprotective agent, fixing the fragments, drying them, and replacing the fractured surfaces. With porous products such as cottage cheese or yogurt, the replicas are thick because platinum as the coating metal and carbon used to support the replica penetrate deep into the specimen. This makes it possible to obtain three-dimensional micrographs. Such micrographs are obtained under a transmission electron microscope and, hence, are superior, as far as the resolution is

concerned, to micrographs obtained by scanning electron microscopy. Lactic bacteria and their filamentous strands and even casein micelles in cottage cheese were successfully fractured and visualized by this new method, giving an insight into the bacteria and the casein micelles that was not possible before the development of this method.

*Process cheese.* In cooperation with Dr. C. A. Ernstrom of the Utah State University, effects of various melting salts on emulsification of fat in process cheese were studied by scanning and transmission electron microscopy (TEM). The salts were found to be in the crystalline (undissolved) form even 40 min after cooking had been started. Some salts showed characteristic shapes that facilitated their recognition. The disintegration of large fat particles was best visualized by TEM.

## Meat quality

Sensory evaluation of meat that results from animal studies at Research Branch stations is continuing. These included evaluation of chickens fed rapeseed meal (at Swift Current), chickens fed potato waste (at Kentville), forage-fed beef (at Melfort), and once-bred gilts (at the Animal Research Institute). A major study of the eating quality of Maturity Class I and Maturity Class II beef in collaboration with the Food Production and Marketing Branch showed Maturity Class I beef to be more tender than Maturity Class II beef.

## Flavor

A description of flavor chemicals listed in 28 categories has been prepared for publication as a Food Research Report. No comparable publication lists the material according to flavor description.

## FOOD SAFETY AND NUTRITION

### Glucosinolate studies

A project on optimum drying of horseradish was carried out and as a result a commercial processor is now producing horseradish with greatly improved quality. Improvement in methodologies for the fractionation and analysis of glucosinolates and their hydrolysis products has been achieved. Participation in a collaborative study on methodology for rapeseed glucosinolates was completed. This study

was initiated by the Research Station, Agriculture Canada, Saskatoon.

### Nitrosamine analysis

A survey of 200 Canadian cured meats other than bacon was carried out under the meat contract research program. The samples were analyzed for six different volatile nitrosamines. All samples were found to be virtually free of nitrosopyrrolidine, nitrosopiperidine, nitrosodibutylamine, and nitrosodiethylamine. Nitrosodimethylamine was detected in very low levels in all classes of the cured meat samples. This nitrosamine is found in a variety of food products and appears to be somewhat ubiquitous. For the most part, all classes average less than 5 ppb of this nitrosamine. Approximately 44% of the cured meats sampled has levels of nitrosomorpholine from 1 to 5.0 ppb. This nitrosamine was eliminated on removal of morpholine-based cleaning compounds from plant clean-up procedures.

### Amino acid derivatives

A new synthesis route for *N*-acyl derivatives of tryptophan and threonine has been demonstrated and these derivatives are being tested for biological activity. Previously synthesized methionine derivatives have been tested for biological activity with results ranging from 100% for stearyl-methionine and its sodium salt to 50% for the stearyl ethyl ester. These methionine derivatives show promise for use in protein supplementation, because they have only 50% or less of the flavor problems associated with the use of methionine alone. Some of the amino acid derivatives developed under this program have demonstrated bactericidal properties in model system studies.

### Proteolysis products

Proteolysis products have been studied at Laval University as intrinsic factors affecting nutritional properties of plant proteins. Protein fractions have been prepared from wheat, soya, and rapeseed and these have been evaluated nutritionally in comparison to animal protein proteolysates. The latter were more rapidly absorbed than similarly treated plant proteins, with casein being the most and rapeseed the least rapidly absorbed. There was a high correlation between nutritive value of food proteins and proteolytic products containing fractions of less than 1000 mol wt.

### Lysinoalanine studies

Toxicity studies at Laval University have shown that free and bound lysinoalanine (LAL) have no effect on renal function in the rat but morphological changes were observed in the distal kidney tubules that were a function of the release and absorption of LAL in rat intestine. Alkali treatment of soya and rapeseed proteins and casein promoted both free and bound LAL formation, with casein producing the most and soya the least. A sensitive HPLC method was developed to measure LAL in blood serum.

### Microbiology

Substantial data have been accumulated on the microbial load on eggs passing through grading stations. These data are currently being used to develop regulations for egg washing.

It has been shown that the problem of late gas in cheese is caused by a microorganism. It has not been possible, to date, to identify this organism.

Contract work continues to expand in this area and covers a wide range of microbiological problems in food safety.

## NEW FOOD INGREDIENTS

### Oats

*Oat gum.* The endospermic cell walls of Hinoat, a high-protein cultivar of oats, contain a high-viscosity gum, which has been purified. Enzyme digestion of the purified glucan with a specific  $\beta$ -glucan endohydrolase (from *B. subtilis*) produced mainly a trisaccharide and a tetrasaccharide. Based on the yields of these, it was calculated that the glucan contains 71%  $\beta$ -1,4-linkages and 29%  $\beta$ -1,3-linkages. Barley  $\beta$ -glucan, similarly treated, appeared to contain 70%  $\beta$ -1,4- and 30%  $\beta$ -1,3-linkages. Interaction of the  $\beta$ -glucan with dye was used to monitor the enzyme digestion. This is a potentially useful technique that overcomes some of the disadvantages inherent in viscosity and reducing sugar assays. The interaction of dyes with cereal  $\beta$ -glucans and other polysaccharides has confirmed that major interaction with both Congo Red and CalcoFluor M2R New is only shown by polysaccharides containing contiguous  $\beta$ -1,4-linked glucopyranosyl units (cellulosic type).  $\beta$ -Glucans interact strongly

with Congo Red only. In the cello-oligosaccharide series, interaction starts at the pentamer level. These results suggest that interaction is controlled by polysaccharide conformation. Attempts to quantitatively analyze the dye-binding curves obtained from spectrophotometric studies have not been successful to date, possibly because of aggregation phenomena. Nevertheless it can be qualitatively shown that there is an increase in dye binding with increased ionic strength. Studies with water-soluble derivatives of cellulose have shown that the degree of substitution of the cellulose chain affects dye binding. Studies of the precipitation of oat  $\beta$ -glucan by CalcoFluor have shown that at high  $\beta$ -glucan concentrations salt inhibits the precipitation reaction, but at lower  $\beta$ -glucan concentrations, salt enhances the precipitation reaction.

*Oat lipids.* The GLC peak appearing in the area of C<sub>4</sub> short-chain fatty acid methyl esters has been shown by GLC/MS and IR analysis to be a mixture of acetals, free fatty acids (FFA), and vinyl esters (the latter may be a contaminant). FFA was estimated to constitute 30–45% of the total GLC peak.

*Oat starch.* Further structural studies on Hinoat starch have revealed that pullulanase, a debranching enzyme, is unable to completely break down the structure of this oat starch. Waxy maize starch, having 99% of the highly branched amylopectin component, is almost totally degraded by pullulanase. Since Hinoat starch is composed of 17% amylose, 26% of an intermediate fraction, and 57% amylopectin, the pullulanase result suggests the presence of certain branch points exhibiting resistance to enzyme attack. The behavior of Hinoat starch in some model food formulations has also been investigated and characteristics of this starch paste in the presence of salts, mild edible acid, and sucrose show behavior distinctly different from other cereal starches. The possibility that these anomalies may be directly related to starch structure are under consideration.

## Oilseeds

*Rapeseed protein concentrate.* FRI-71 process rapeseed concentrate (RPC) incorporated in a diet at 20% protein level, supplemented with zinc (150 mg/kg), and fed to young weanling rats for 16 wk showed no significant effect on body weight, Zn, Fe, Cu, and Ca levels in serum, liver, testes, and

femur. Serum and femur Mg levels (but not liver and testes) were slightly elevated but there was no gross adverse effect.

An alternative detoxification process (FRI-75 process) for RPC preparation has been patented in the USA and licensed in Canada. Development work is in progress.

Contract studies at University of Toronto on an improved process for preparation of rapeseed protein isolate has reduced the effluent phosphorus (P) generated, as well as the P content of the isolate, and improved product color, flavor, and protein content with minimal losses of protein and functional properties.

A contract to study the effect of phytate on the nutritional and functional properties of rapeseed protein has been completed. Low phytate rapeseed isolates were prepared by alkaline extraction and isoelectric precipitation with CMC as an aid. Feeding trials with phytate varying from 0.01% to 1.24% of diet showed an inverse relationship between rat performance and phytate content. Phytate had marked effect on serum and femur Zn levels.

## Whey utilization

The use of whey protein concentrate (WPC) in food was expanded by modifying the functional properties of this whey by-product. Heating whey at 90°C for 15 min in the pH range of 2.5 to 3.5 produces a product that was previously shown to have enhanced water binding capacity, resistance to thermal discoloration, and good solubility and gelation properties.

Additional samples of WPC were prepared by ultrafiltration (UF) for further study of the functional properties. The water hydration capacity (WHC) ranged from 0.95 to 1.68 and was affected by two variables: heating after UF increased WHC from the range of 0.95–1.55 to 1.42–1.68; and higher pH of heating, i.e. pH 3.0 and 3.5, increased WHC. Commercial samples of WPC had WHC of 0.55–1.02.

The coagulation temperature of the acid heat WPC is affected by both the method of processing and pH of reconstitution. Heat at pH 1.5 and reconstitution at pH 7–8 resulted in the WPC coagulating at 72°C versus 71 for liquid egg albumen. This coagulation temperature could be lowered by as much as 20 deg by changing the pH and point of heating; higher pH levels (e.g. 3.0 and 3.5) tended to

lower coagulation temperature; heating after ultrafiltration also reduced coagulation temperature. Commercial samples of WPC coagulated in the temperature range of 61–99°C, depending upon product and pH in reconstitution.

The least coagulable protein concentration (LCPC) varied from 1.5 to 3.6% and was also dependent on both the pH of heating and method of processing. Samples heated at pH 3.0 and 3.5 after UF tended to have higher LCPC. Commercial WPC had LCPC that ranged from 1.3 to 6.6%, depending upon manufacturer and pH of reconstitution. Egg albumen was used as the control sample and had LCPC that ranged from 0.15% at pH 5.0 to 2.75% at pH 8.0.

Efforts to determine the underlying physicochemical basis for the effects of acid heat treatment on whey protein functionality have continued. Several pilot-plant-produced WPC were examined by methods previously used in model denaturation studies on  $\beta$ -lactoglobulin. WPC prepared by heating after concentration of whey by ultrafiltration showed greater insolubility of pH 2.5, increased denaturation (as pH 4.5 insoluble), lower  $\beta$ -lg/ $\alpha$ -1a by electrophoresis, and smaller

DSC endothermic peaks than the corresponding WPC prepared by heating whey before concentration by ultrafiltration. In both processes, WPC prepared from whey at higher pH contained more denatured proteins. The nature and extent of denaturation of whey proteins influences their functional properties.

Thermal denaturation studies in model systems was extended to include measurement of changes in viscosity and enthalpy (DSC). Changes in intrinsic viscosity [ $\eta$ ] of  $\beta$ -lactoglobulin solutions heated (90°C) at pH 2.5 up to 60 min and their pH 4.5 insoluble and soluble fractions were determined. The [ $\eta$ ] of native  $\beta$ -lactoglobulin (3 mL/g) increased (7.3 to 13.2 mL/g) with time of heating. The [ $\eta$ ] of  $\beta$ -lactoglobulin unfolded by guanidine hydrochloride was 19.1 mL/g. Thus, unfolding caused by heating was partial. This observation is in agreement with previous optical rotation measurements.

The denaturation of  $\beta$ -lactoglobulin at pH 5.0–7.0 and in the presence of an anionic detergent (SDS) was studied by differential scanning calorimetry. Small amounts of SDS (<5 mM) delayed endothermic reaction, whereas larger amounts (>20 mM) hastened it.

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# Land Resource Research Institute

## Ottawa, Ontario

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C. A. FOX, B.A., M.Sc., Ph.D.	Micromorphology
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H. N. HAYHOE, B.Sc., M.S., Ph.D.	Biomathematics
D. W. STEWART, B.S.A., M.Sc., Ph.D.	Micrometeorology
R. B. STEWART, B.A., M.Sc., Ph.D.	Applications
C. E. OUELLET, B.A., B.Sc.A., M.Sc.	Ecoclimatology

## Departures

V. I. BURACHYNSKI, B.Sc. Resigned 27 April 1979	Party leader
R. M. MARCOUX, B.Sc., M.Sc. Resigned 20 April 1979	Head of Unit
A. BRUNELLE, B.S.A., M.Sc. Resigned 15 June 1979	Party leader
C. G. HEATH, B.Sc. Resigned 27 September 1979	Party leader
H. C. SLAVINSKI, B.Sc., M.Sc. End of term position, 12 October 1979	Party leader
G. D. V. WILLIAMS, B.S.A., M.A. Transferred to Atmospheric Environment Service, 1 June 1979	Crop information
W. B. BAIER, Diplomlandwirt, Dr. agr., M.Sc. Seconded as Acting Director of Chemistry and Biology Research Institute, 14 May 1979	Head of Agrometeorology Section

## VISITING SCIENTISTS

### *National Research Council postdoctorate fellow*

L. M. DWYER, B.Sc., M.Sc., Ph.D. <i>Transfer of work from National Institute of Agricultural Science, Tokyo, Japan</i>	Agrometeorology
Y. KATO, B.Sc., M.Sc.	Information systems

## INTRODUCTION

In April 1978, the Land Resource Research Institute (LRRI) was established to bring together the main professional disciplines involved in agricultural land resource studies within Agriculture Canada. To achieve this, the Institute focuses on three main activities: (1) the assembly and integration of information on land forms, soils, and climate and their interactions relative to the evaluation of land resources for potential agricultural and related uses; (2) the collection and synthesis of information on the seasonal dynamics of weather and its effects on land use and food production; and (3) the undertaking of research as required to meet the needs of the first two functions. To meet these requirements, activities of the Institute focus on the physical aspects of land that determine its potential for various uses and on the influence of weather on these potentials.

This report briefly outlines the Institute's organization, programs, roles, progress, and major achievements during 1979. Requests for details should be addressed to: Land Resource Research Institute, Agriculture Canada, Ottawa, Ont. K1A 0C6.

J. S. Clark  
Director

### ORGANIZATION OF THE INSTITUTE

During 1979, revision and updating of the LRRI programs were completed. Institute activities were organized into an administrative section, a laboratory and field staff that serves all Institute programs, and four research and service programs. The latter are organized as follows:

- (1) Soil resource inventory and mapping
- (2) Soil classification
- (3) Land use and evaluation
- (4) Agrometeorology.

Program functions, goals, and main project areas of these programs are summarized below.

#### Soil resource inventory and mapping

*Function.* The functions of this program are to conduct soil inventories and to publish reports and maps required for land use planning and agricultural land development. This includes preparing guides for rating soils, providing soil ratings for various uses, producing derived and interpretive maps, and presenting soil and landscape properties and generalized descriptions of soils.

*Goal.* The program's goals are to complete the inventory of critical areas of Canada, to extend the soil survey coverage to new areas, to apply improved systems for taxonomic and interpretive classifications, and to develop improved mapping systems.

*Program projects.* Thirteen projects are contained in this program including:

- (A) Inventory (11 projects)—to complete the resurvey of selected areas of Canada and to extend soil survey coverage to new areas with potential for agricultural and other developments;
- (B) Correlation—to improve the quality and consistency of soil classification, mapping, and interpretations;
- (C) Mapping and cartography—to develop improved mapping and cartographic procedures and standardized mapping systems according to the scale and purpose of the survey.

#### Soil classification

*Function.* The function of this program is to improve the taxonomic and interpretive classification of Canadian soils by research and analysis of new soil information.

*Goal.* The program's goal is to develop improved methods and criteria for characterizing organic and selected mineral soils, for characterizing and modeling soil water regimes, and for interpreting soil information for specific purposes.

*Program projects.* Three projects are contained in this program:

- (A) Organic soils—to develop improved procedures for characterizing, classifying, and managing organic soil;

- (B) Mineral soils—to improve the characterization and understanding of genesis of selected mineral soils, to refine classification criteria as necessary, and to develop and test a system for engineering interpretations of soil survey information;
- (C) Soil water and structure—to develop and apply improved methodology for soil-water measurements and to further the understanding of soil-water retention and movement in structured soils as a basis of developing a process model of the water regime of soils in the landscape.

### Land use and evaluation

*Function.* The function of this program is to establish national systems for integrating and interpreting soil, climate, landform, agronomic, and economic data for evaluating the potential of land for various alternative agricultural uses and maintaining the quality of the land resource for production.

*Goal.* The program's goal is to develop improved methodology for evaluating, protecting, and interpreting the capability and quality of the soil resources of Canada for the purposes of land-use decision-making and policy assessment.

*Program projects.* Included in this program are four projects as follows:

- (A) Soil information systems—to improve existing methods and to develop new computerized techniques for collating, storing, and interpreting soil-resource and crop-yield data for purposes of land evaluation, land-management recommendations, soil interpretations, and monitoring of land degradation;
- (B) Crop production potentials—to develop procedures for predicting yield at various scales as a function of soils, climate, and management, for all economically important crops in Canada;
- (C) Resource protection—to develop an improved inventory of soil degradation processes (such as erosion) and to compile preliminary assessments of the relation of these processes to water quality, land use, and soil management;
- (D) Land use and socioeconomic evaluation—to develop procedures for integrating environmental, agronomic, and

socioeconomic information for the systematic evaluation of the agricultural land-use potential of Canada's land resources.

### Agrometeorology

*Function.* The function of this program is to develop and apply improved methodology for the assessment of agroclimatic resources and crop-weather relationships as they affect land management and crop production in Canada.

*Goal.* The program's goal is to develop improved methodology for the assessment of agroclimatic resources and for analyzing and monitoring crop response to weather, soil, and land management in order to provide agrometeorological information as required for agricultural research and services, and as an input to planning, marketing, and farm-management decisions.

*Program projects.* Four projects are contained in this program:

- (A) Climate—to develop improved methodology for the assessment of agroclimatic resources and to provide agroclimatological information leading to more efficient management of national resources for food and fiber production;
- (B) Crop information—to develop systems for evaluating the areal extent, growing conditions, and yield prospects from remote sensing, soil information, and statistical and meteorological data for improved marketing information on the national and international supply aspects of selected crops;
- (C) Applications—to provide agrometeorological information in support of agricultural research and services and to interpret meteorological data in a form most useful in planning and management of farm operations;
- (D) Crop and weather systems—to improve crop environmental data acquisition systems at all scales and to develop simulation and statistical-type models using physical or physiological and mathematical concepts thereby providing basic knowledge of soil-crop-atmospheric systems in order to increase the efficiency of resources utilization and management practices in crop production in Canada.

## INSTITUTE ROLES

Activities of the LRRRI include research, development, and services related to Canada's land resources. These activities not only support other research within the Research Branch but also provide information essential to policy and decision making for regional and national levels of governments, educational institutions, and agribusiness. In pursuit of these activities, the Institute provides leadership and is responsible for a number of national programs related to land including those outlined below.

*Soil inventory.* Soil mapping is done by LRRRI staff in cooperation with provincial and university personnel throughout the nation, and correlation provides a measure of quality control of soil maps and reports. Maps are prepared showing the distribution of soils and the land capability for various potential uses.

*Computerized soil and land information system (CanSIS).* Soil survey, soil management, crop yield, and cartographic data are stored so as to be available to users throughout Canada.

*Soil taxonomy and interpretations.* Improvements are developed in taxonomic and interpretative soil classification systems through research and integration of information from many sources.

*Land evaluation.* Soils, climate, agronomic, and economic data are being integrated to develop improved methodology for predicting crop-yield potentials and assessing the quality of the land resources of Canada for various uses.

*Agrometeorological data archive.* Agrometeorological data and processing services are provided.

*Crop information system.* Agroclimatic resource maps and statistical and remote sensing data are being integrated to develop a system for monitoring the areal extent, growing conditions, and yield prospects of selected crops.

*Committees.* The LRRRI contributes to the integration of land-related activities of Agriculture Canada and other federal and provincial agencies through participation in a number of committees. These include:

- Canada Committee on Land Resource Services (CCLRS) and the associated expert committees

- provincial agricultural services coordinating committees and soil survey committees
- Canada Committee on Ecological Land Classification
- Interdepartmental Committee on Land Use
- Interdepartmental Committee on Water
- Geotechnical Committee of the National Research Council
- Canada Advisory Committee on Remote Sensing
- Committee on Great Lakes Water Quality.

## INSTITUTE PROGRESS AND ACHIEVEMENTS DURING 1979

### Soil resource inventory and mapping

The soil resource inventory and mapping program involves personnel of the soil survey units throughout Canada and a group at headquarters of the Land Resource Research Institute in Ottawa concerned with soil correlation and cartography. The survey projects are conducted in cooperation with personnel of provincial agencies following working priorities that are established in the provinces through consultation and mutual agreements. Many of the federal soil survey units share offices and other facilities with their provincial counterparts. Unlike previous annual reports, the report which follows includes only the resource inventory and mapping carried out by the federal soil survey staff.

*Newfoundland.* The soil report and map of the Codroy area have been published. The reconnaissance survey of the Avalon and Bonavista areas has been completed and the reports were submitted for editing and publication. Soil survey reports for the Cormack and Port au Port areas have been completed and are ready for editing. Soil mapping is progressing in several projects in the province. A detailed soil survey is being carried out in the Terra Nova area and an exploratory soil survey is being conducted in the Gander Lake area. Interim soil maps and soil capability maps have been compiled for both of these latter projects.

*Prince Edward Island.* Soil information has been presented on photomosaic maps (scale 1:10 000) for 60% of the province, and these map manuscripts have been sent to the



cartography unit for publication. Ten percent of these photomosaic soil maps have been transferred to smaller-scale line maps which provide a generalized soil map for the province. In addition to this, interpretive matrices were completed for two test areas and from these, using the CanSIS system, 10 single factorial and interpretive maps for different uses were generated.

*Nova Scotia.* The reports *Soil of the Atlantic Region* and *Key to the Soils of Nova Scotia* were completed. Reconnaissance soil mapping was conducted in Pictou county and approximately 75% of the mapping has been completed. A regional workshop on soil erosion was conducted, with the main emphasis being on the causes and consequences of soil erosion in the province. The Quebec and Maritime (Q and M) pipeline environmental maps were evaluated and mitigation measures were reviewed.

*New Brunswick.* The soil report and maps for the Richibucto–Rogersville area were completed and submitted for publication to Research Program Service. A detailed soil survey of Part 1 of the Sussex area was completed, interim maps were prepared, and sections of the soil survey report were partially completed. The Q and M pipeline environmental maps were evaluated and mitigation measures were reviewed.

*Quebec.* A detailed survey was completed in a portion of the St-Hyacinthe area. Soil legends and preliminary maps were completed for the Temiscouata, Arthabaska, and Charlevoix map areas. The Q and M environmental maps for the proposed gas pipeline route were evaluated. The LRRRI mitigation measures were evaluated and a translation of the bulletin *Possible Impact of Pipeline Construction on Farmland* was prepared. This bulletin summarizes the findings of the Quebec, Nova Scotia, and New Brunswick groups.

*Ontario.* Draft soil reports were completed on contract for the Dryden-Kenora and Rainy River sheets and for Pukaskwa National Park. The draft report and soil maps for the Middlesex map sheet have been completed. Detailed soil mapping has been completed in the Norfolk–Haldimand area and approximately 90% of the reconnaissance survey has been completed in the Ottawa–Carleton area. In addition to this, soil reports of the Peterborough area reconnaissance soil survey and

the Brant area detailed soil survey have been edited. Research was conducted on interpretation of soil-survey information, soil-mapping systems, soil-water regimes, soil erodability, and the relationship of soil-erosion processes to soil-management practices.

*Manitoba.* Soil reports were published for three detailed project areas (Oak Lake, Grindstone Point, and Glenboro) and a reconnaissance soil report was published for the Split Lake – Sipiwesk project area. In addition to this, soil reports for the Bird River, Lac du Bonnet, and Ste-Rose areas were completed and submitted for publication. Detailed soil mapping was carried out and completed in select areas of South Riding Mountain, West Interlake, Swan River Townsite, Dauphin, West Portage, and Whiteshell planning districts. Reconnaissance soil mapping was completed in the Hadashville and Rat River organic soil study areas. Project reports were completed for physiographic regions of Manitoba, and for guides for rating soils for engineering uses, soil-water regime, and soil-mapping systems.

*Saskatchewan.* Draft reports were completed and submitted for editing for the Waterhen, Green Lake, Wapewekka, Swift Current, and Hudson Bay – Swan Lake detailed soil survey projects. Reports were also completed on a variety of lesser projects that included: a detailed soil survey of Newcombe community pasture, a soil-salinity and groundwater study, and a study of soil resources for park planning and management for Parks Canada.

*Alberta.* Soil maps and a legend for the Lethbridge area were completed and submitted to cartography. Soil maps and a legend for Newell county were completed and given restricted circulation to selected users. The Brazeau dam area maps and report are in final publication stage. A generalized map of Solonchic soils in Alberta was completed to editing stage. Mapping was completed in the Banff–Jasper area and in one-third of the Warner County area. Technical advice was provided to provincial agencies on modification of soil irrigability ratings, municipal assessment manual, crop-yield information related to hail and crop insurance, and management of Solonchic soils.

*British Columbia.* The reconnaissance soil survey report of the Princeton area has been published. The soil and derivative maps for

the Mill-Woodfibre project area were submitted for printing. Soil reports for the Quesnel and Lac La Hache - Clinton projects were completed. A detailed soil survey was completed on selected areas on the Gulf Islands and in the Power River area. Work continued on the Tanzanian wheat project (the unit has been involved in this project for several years). The Tanzanian soil and wheat suitability maps were edited and submitted for publication.

*Ottawa.* The correlation staff, in conjunction with provincial correlators, conducted correlation studies in many areas: Caribou wetlands in British Columbia, Norfolk-Haldimand and Ottawa-Carleton areas in Ontario, Beaver County in Alberta, and the Weyburn-Melville area in Saskatchewan. They collectively completed a manuscript *Recommended Soil Correlation Procedures*. Further development and testing of the soil-water regime classification and of the soil-mapping system were conducted. Soil reports and map legends were edited for Brazeau Dam, Lardeau, Nelson, The Pas, Seymour Arm, L'Islet, Bonavista, Richibucto-Rogersville, Madawaska, Codroy, Avalon, and others. Liaison was maintained with the National Energy Board, and evaluation of the Q and M pipeline environmental maps was conducted and coordinated. A bulletin *Possible impacts of pipeline construction on farmland* was completed.

*Cartography.* A manual *Screens for Thematic Map Production* was completed and distributed to all survey units. Semicontrolled photomosaic maps were completed for Warner County and Melville sheet; this is a new product line. Displays were prepared for Soil Conservation and Food Dialogue meetings. Maps completed were: soils 52, special projects 14, miscellaneous LRRI 114, other branches 73, other departments 11. The CanSIS cartographic file equipment saw 196 maps added and processed; 1050 plots were completed, of which 25% were requested by other agencies.

In the Canada Land Inventory and Northern Land Use information on projects carried out on behalf of Department of Environment, 103 maps were completed.

## Soil classification

The soil classification program is directed to research relating to organic and mineral soils and soil-water problems. A new electromagnetic method for measurement of water content of soils was developed and is to be funded for production as a commercial instrument.

*Organic soil characterization and classification.* The project leader completed a year of transfer work in France where he made progress in the botanical and micromorphological characterization of peat materials. These techniques as well as physical and chemical methods are being used in a detailed characterization study of a wide range of organic soil materials from different areas of Canada. Results of this study contribute to the development of improved criteria for differentiating, classifying, and evaluating the agricultural potential of organic soil types. Cooperative studies with the Saint-Jean Research Station, the Chemistry and Biology Research Institute (CBRI), and the Quebec Department of Agriculture are on schedule, and two joint papers with CBRI were published on factors affecting the subsidence of organic soils.

*Mineral soil characterization and classification.* Two papers were prepared on the evaluation of criteria for estimating illuvial clay in the B horizons of Canadian soils. They show that refinements are needed in both field and micromorphological procedures for estimating clay translocation. A paper published on the classification of sandy soils in New Brunswick showed that nearly all of them are Podzolic soils and that their B horizons are markedly enriched in clay. Two papers were published on the properties and genesis of Podzolic soils with ortstein. Energy dispersive X-ray microanalysis shows that the cementing material of ortstein is a complex of humified organic matter with aluminum or with aluminum and iron. Similar work with the strongly cemented duric horizons from British Columbia indicated that mixtures of amorphous aluminum, silica, humus, and iron probably were the cementing agents. A report summarizing information on background levels of minor elements in Canadian soils was published and two scientific papers were prepared from the material. Work on the development of a procedure for checking the reliability of classification of soils in map units is ahead of

schedule and preliminary field testing has been done. Drafts have been prepared of reports on a system of interpreting soil-survey information for engineering uses of soils, and on the application of this system to the Nepean-Gloucester area.

*Soil water and structure.* Four soils of differing texture and structure were selected and sampled to depths of 1.5 m for general characterization and for detailed studies of porosity - structure - water relationships. Monthly observations of macrostructure revealed no significant seasonal changes. Detailed laboratory studies of structure - hydraulic conductivity relationships are in progress. Good progress was made in the development of time domain reflectometry (TDR) as a rapid, convenient technique for measuring soil water in the field. Three papers were published on the theory and application of the technique and papers were presented on it at three scientific conferences. Refinements of the technique are in progress.

#### **Land use and evaluation**

Land use and evaluation is a new program in the Institute directed to the development of national systems for integrating and interpreting soil, climate, landform, agronomic, and economic data for evaluating the production potential of land for various alternative agricultural uses. The initial phase of the program efforts has been directed at research and development of methodology and the establishment of systems for managing and interpreting the extensive data that are required for the prediction of potential returns from a given tract of land. Activities and progress within each of the four project areas is reported as follows.

*Soil information systems.* A number of improvements were made in the computer system, for retrieval and storage of soil-map information and for handling of productivity and related data for the performance-management file, constituting a major step toward the development of a fully operational computerized soil-map system. In this regard work was completed on procedures for producing derived maps and for computerized map symbol replacement. In addition, programs and methodology for production of extended legends, increasing matrix size for data storage, and logging map data were begun. The Caledit software package was

evaluated and preliminary work was done on data exchange formats with other agencies.

In the data management system a number of improvements were made including routines for file management, and data conversions with FITSOL (Europe). Initial work was started on development of multifile capacity, point in polygon, improved data output programs, and other aspects of data management. A manual for the CanSIS performance-management file is being printed to provide guidance on the operation and use of the system.

Data exchange with France, Belgium, and a number of African countries has continued.

*Crop production potentials.* Climate data compilation required for use in mapping the Canadian Great Plains region was completed and preparation of 1:1 million scale maps was initiated.

Phenological crop-yield models have been developed for spring wheat, maize, soybeans, potatoes, and phaseolus beans.

A data bank of actual crop yields from crop reporting districts has been assembled and linked to the *Soils of Canada* map (1:5 million).

Three papers on soil-water research and one review article on soil-moisture research in Canada were prepared. Preliminary equations on 1/3 and 15 bar moisture contents were developed.

*Resource protection.* A report on the types and extent of soil degradation in Canada has been prepared as a base for work planning. First draft guidelines for agricultural land management to minimize Great Lakes pollution have been prepared. Studies on the effect of pipeline construction on soils were extended to include physical compaction.

A computer technique for mapping soil-erosion susceptibility was completed. Initial work to assess the effect of cropping practices on soil degradation, field monitoring of erosion in the Peace River area, and effect of tile drainage on water tables in the South Nation River drainage basin has begun. Monitoring of manure storage and of manure and fertilizer applications was continued.

*Land use and socioeconomic evaluation.* A data base for estimating land-production potential has been established, Canadian production potential for five crops has been determined, and a first draft of a report to the Food and Agriculture Organization (FAO)

has been completed. Work has been started on modeling the distribution of agriculture relative to climatic and soil resources. A land-resources evaluation report for Nova Scotia has been completed. Analysis of data for land-use inventories in the Ottawa Carleton and Melville map areas has been summarized.

### Agrometeorology

Agrometeorology is concerned with the interaction of hydrometeorological factors and soils as they affect agriculture and food supply. Discovery and definition of these relationships and application of this information toward more effective land use and crop production are of primary concern. Progress reported for 1979 is as follows.

*Climate.* Development of the FAO crop-productivity model for assessing the agroclimatic suitability of wheat, corn, soybeans, potatoes, and phaseolus beans was completed for Canada. Mapping of the various suitability ranges for these crops was started. Application of the crop suitability estimates for determining the potential productivity for these crops was initiated and the required programs were developed.

*Applications.* An assessment of climatic resources in the Maritimes undertaken cooperatively by LRRI and the Policy, Planning, and Economics Branch for a land-evaluation study was completed.

Data from 200 meteorology stations were used to develop climatic models for soil-moisture reserves, grasshopper surveys, and other service requests.

The technique developed to study the periods and climatic factors affecting alfalfa winter survival was applied to spring wheat and the results were documented.

The first draft of a report on soil temperatures and its implications requested by *La Commission d'Agrométéorologie du Québec* has been completed.

*Crop information.* Selection and evaluation of crop models suitable for measuring crop production using "real time" weather and crop conditions data for estimating crop yields in Canada and the USSR was undertaken

toward development of a crop information system. The suitability of LANDSAT imagery for assessing crop conditions was evaluated for test areas in Western Canada (spring wheat) and in Kansas (winter wheat). Estimates of yields of spring wheat and winter wheat were made for crop districts in Western Canada and in Russia using generation I regression models for evaluation against crop reports.

Evaluation of the components required for development of a pilot crop information system has been completed, and a proposal has been submitted for Departmental consideration.

The high-resolution field spectroscopy study carried on from 1975 to 1978 to determine spectral characteristics of various crops was completed and the results were published.

*Crops and weather systems.* The effects of weather factors on corn growth in the field were monitored with a complete set of growing-season biological and environmental data obtained for a corn crop. Net assimilation and transpiration rates were obtained with leaf chambers throughout the growing period.

New devices to provide measurements of percentage ground cover, leaf wetness, and diffuse radiation were respectively completed, built, and designed and built. A microprocessor system was assembled and programmed to measure soil moisture using the TDR technique.

A technique to determine the importance of various phases of wheat growth on final yield was published. A detailed model of soil-water extraction by plants was developed and incorporated into a forage dry matter model and a spring wheat yield and protein content model. The latter model is currently in the process of being used to evaluate the annual variations in field and protein content of spring wheat in Western Canada.

A computer program implementing the Markov chain modeling procedure used for workday probability estimation was completed. Development and testing of a nonlinear diffusion model for corn root density as a function of time was undertaken, and the results were documented.

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# Research Institute

## London, Ontario

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### Departure

E. Y. SPENCER, B.Sc., Ph.D., F.C.I.C. Retired 26 October 1979	Special Assignment Program
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P. STÖSSEL, Licenciante, Ph.D., 1978–	Plant pathology: phytoalexins
P. AHMAD, B.Sc., M.Sc., Ph.D., 1979–	Membrane biochemistry

#### *Graduate students*

A. B. BROADBENT, B.Sc. (Hon.), M.Sc. 1977–	Pesticide ecology
M. A. J. FINKELMAN, B.Sc., M.E.Sc., 1979–	Biochemistry

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## INTRODUCTION

This report summarizes highlights of research carried out during 1979 at the London Research Institute in support of the Departmental objectives in environmental quality and crop protection. The Institute was established in 1951 to investigate the problems created by the introduction of synthetic organic pesticides. Present research programs reflect the current health and environmental concerns regarding the agricultural use of pesticides by concentrating effort in the areas of integrated pest management and environmental toxicology.

The integrated pest management (IPM) objective comprises four research activities. Pest management research is aimed at developing IPM procedures for agriculturally economically important insect pests involving the minimum use of pesticides. Research in the stored products area is aimed at environmental and insect resistance problems and the development of more efficient fumigation procedures leading to minimum pesticide residues. Activity three is concerned with research on alternative pest control strategies. Basic studies on insects are aimed at identifying specific areas for attack so that pest control in the future will not rely upon the use of broad-spectrum toxicants. Research on natural plant defense mechanisms in disease resistant and susceptible agriculturally important crops has the aim of utilizing natural defense mechanisms by chemical manipulation or in the breeding of resistant varieties. The last activity under the IPM objective is concerned with research on systemic fungicides. Studies are carried out on the efficacy of systemic fungicides and the plant pathological, biochemical, biophysical, and structural parameters involved in fungicide activity and resistance.

Research on environmental toxicology has three areas of activity. The first area of work is on the effect of pesticides on nontarget soil invertebrates and agriculturally important soil microorganisms. The second activity relates to the development of pesticide methodology required to determine the behavior, persistence, and environmental fate of pesticides. The last activity is concerned with establishing the mode of action of growth regulators and toxicants by carrying out studies in insects and plants related to vital processes involved in growth and development.

Dr. E. Y. Spencer retired in October 1979, after 16 yr as Director at London.

This report records only the highlights of our accomplishments for 1979; more detailed information can be obtained from the publication titles listed at the end of this report. Copies of this report, reprints of publications, and further information are available on request from the Research Institute, Agriculture Canada, University Sub-Post Office, London, Ont. N6A 5B7.

H. V. Morley  
Director

### INTEGRATED PEST MANAGEMENT

#### Pest management

The sterile adult release program for successful integrated control of the onion maggot requires large-scale rearing of the insect. Field rearing offers obvious economic advantages over laboratory rearing. Experiments in overwinter rearing of the onion maggot in the field yielded over 2 million pupae from a relatively small area. Attempts to rear two further generations over the summer resulted in approximately 90% reduction in yield of pupae due to natural biological control from

predators and parasites. Twenty-two arthropod predators and four parasites have so far been identified together with the stage in the onion maggot life cycle which they attacked. One of the parasitic Hymenoptera was found to be particularly voracious, and rearing techniques were devised for mass production in the laboratory with a view to carrying out biological control experiments in the Thedford Marsh. Other field studies were carried out on the chemical control of the cabbage maggot, Colorado potato beetle, tomato hornworm, and onion maggot in microplots at the Institute field station, with promising results. Further crop loss studies were conducted on potatoes and onions at the Thedford Marsh.

Baseline toxicity data were obtained for some organochlorine, organophosphorus, carbamate, and pyrethroid insecticides on susceptible strains of carrot rust fly; onion, cabbage, and seedcorn maggots; darksided cutworm; and tomato hornworm. Selection of parathion-, carbofuran-, and fonofos-resistant strains of the onion maggot was continued. Tests on a strain of Colorado potato beetle from Sherbrooke, Que., indicated that it was highly resistant to carbofuran. In addition, it was shown that the strain was resistant to other organophosphorus, carbamate, and cyclodiene insecticides currently recommended for control. It was shown, however, still to be susceptible to the synthetic pyrethroid insecticides. Other results on a DDT-resistant strain of Colorado potato beetle from Leamington, Ont., indicated that cross-resistance extended to the pyrethroid insecticides. Emerging resistance problems were further documented in a cooperative study with the University of Guelph. It was shown that house flies collected from a dairy operation with a long history of natural pyrethrin use rapidly developed resistance to the synthetic pyrethroid insecticides. One strain of house fly showed signs of resistance to every organochlorine, organophosphorus, carbamate, and pyrethroid insecticide tested.

Pest monitoring is an essential part of an integrated control program and studies on the isolation, purification, and identification of pheromones for use in traps continued. Extracts were prepared from abdominal tips of female tomato hornworm moths. Electroantennogram (EAG) responses to a number of synthetic substances and to ether extracts of female abdominal tips were determined. Attempts to trap male moths in the field using extracts, synthetic chemicals, or even virgin females failed. The trap design that worked well for the tobacco hornworm did not appear to work for the tomato hornworm. Several synthetic insect sex pheromones were purified and used to monitor populations of the European corn borer, fall armyworm, and black cutworm. Work on the development of a predictive model for the emergence of overwintered European corn borers was completed. (*Z*)-7-Dodecenol and mixtures of this compound with other  $C_{12}$  and  $C_{14}$  alcohols and acetates caught significant numbers of male white cutworm moths when tested in Quebec in a cooperative venture with L'Assomption. Attempts to detect the pheromone in laboratory-reared insects, however, failed.

A basic requirement to the effective use of pheromones is an understanding of pheromone reception systems in the insects. Electrophysiological studies on the European corn borer response to the sex pheromones (*Z*)- and (*E*)-11-tetradecenyl acetates was continued. A new more reliable EAG method was developed based on a constant speed air flow rather than the pheromone puffing method. Experiments with a nerve impulse blocking agent, tetradoxin, established that stimuli are conducted actively in the afferent neuron in the insect antenna whereas the initial depolarization at a dendritic region of the receptor cell seemed to spread passively.

### Stored products

Studies in the area of stored products-fumigant research are being carried out to overcome problems caused by resistance of insects to the few fumigants still available for commercial use. Increasing concerns over the toxicological properties of many of the older fumigants has led to the need for research on integrated methods of control. Fumigation of the granary weevil and confused flour beetle with  $^{14}C$ -methyl bromide showed that initially the major reaction product formed was *S*-methylglutathione with subsequent formation of *S*-methylcysteine. In resistant insects an additional product was formed which has not yet been identified. These preliminary results indicated that resistant insects detoxify larger amounts of methyl bromide than the nonresistant strains and that glutathione conjugation is the main detoxification pathway.

Controlled atmosphere studies were continued on the granary weevil and confused flour beetle with regard to resistance to carbon dioxide. It was shown that the degree of resistance leveled off to about three times normal, with selected insects being able to withstand levels of 42% and 75% carbon dioxide for 40 and 15 days, respectively. The characteristics of the insect that enable them to develop resistance to  $CO_2$  are being investigated. Desorption studies of  $^{14}C$ -ethylene dibromide from wheat showed that losses of residual fumigant were closely related to humidity levels during the aeration period. Greatest desorption occurred at high humidity and low temperature. Experiments on phosphine sorption and desorption from wheat or corn showed that desorption occurred rapidly for the first 2-3 days and then

declined slowly, but detectable levels were still present after 220 days.

### Alternative pest control strategies

*Plant diseases.* Research in this area is directed toward obtaining an appreciation of the basic processes involved in plant-pathogen interactions in resistant and susceptible crops. The potential benefits of these studies would be the ability to activate the plants' natural defense mechanisms and to provide guidelines for breeding for genetic resistance.

In the continuing studies on new experimental fungicides, the drop diffusate technique, originally designed to screen soybeans for resistance to *Phytophthora megasperma* (PMS), was successfully adapted for use as an assay system for evaluating systemicity and efficiency of control of fungicides against spore-producing fungal pathogens. The modification resulted in a rapid, highly reproducible, economical assay system. Using this assay procedure, it was shown that in the presence of Ridomil®, soybean cultivars produced lesions characteristic of an incompatible reaction when inoculated with a compatible race. This response was accompanied by the production of the phytoalexin glyceollin, an indication that certain systemic fungicides, e.g. Ridomil®, may owe their activity to their ability to stimulate natural plant defense mechanisms. Methods were developed for the isolation of Ridomil® from plant tissue and its determination by bioassay. In vitro assays demonstrated that Ridomil® and other acylalanines had little effect on spore germination and germ tube growth but were highly effective against mycelial growth. In a cooperative venture with Harrow and Ridgetown (Ontario Ministry of Agriculture and Food), attempts were made to incorporate Ridomil® directly into the seed using polyethylene glycol as a carrier. Test trials in the laboratory yielded promising results but field trials at Ridgetown established that efficiency of disease control was inferior to simpler techniques.

Other studies have established that the resistance of soybean hypocotyls to PMS infection was eliminated by heat shock, chloroform, or actinomycin D treatment. This effect appeared to be accompanied by changes in penetration and glyceollin production. Extensive studies were carried out on the differences in degree of resistance and susceptibility of young and mature tissue of the soybean hypocotyl to PMS infection. Results

obtained showed that soybean hypocotyls became increasingly resistant to both compatible and incompatible races of PMS with age. Results obtained implicated the epidermal cell layer as having the main burden for prevention of parasitism at these mature sites. In a collaborative project with Harrow the zoospore-hypocotyl inoculation system was used to investigate some aspects of the genetics of resistance of soybeans to PMS. Results obtained from 20 cultivars showed that the gene for resistance and glyceollin production in response to race 1 infection was not influenced by other features of the genome. Preliminary results with the system indicated that it would be a valuable tool for genetic analysis of soybean resistance.

Research into the biosynthetic pathways of phytoalexin production continued. Cultures of *Alternaria solani* were shown to reduce the phytoalexin lubimin to the less toxic 15-dihydrolubimin. The fungus also induced the formation in potatoes of the new stress compound 2-epilubimin, which was subsequently converted to 2-epi-15-dihydrolubimin. Experiments with potatoes and *A. solani* confirmed that altersolanol A was enzymatically converted to the microbial metabolite macrosporin, an anthraquinone. The phytotoxic alternaric acid was not formed in infected potato tissue in significant amounts and neither stimulated nor suppressed phytoalexin production in potatoes and peppers.

*Insect pests.* Research in this area is directed toward gaining an understanding of basic life processes in the insect so that methods of selective, specific control can be developed which do not rely upon pesticides that are broad-spectrum poisons. An in vitro assay for chitin biosynthesis was developed and used to evaluate some established and potential chitin-inhibiting compounds. In the continuing study of the molting process, the characterization of a unique epidermal cyclic nucleotide-dependant protein kinase in insect tissue was completed. This unique enzyme was shown to be active only during the molting period and thus provides a specific target site for potential integrated control. Preliminary findings with nematodes indicated that a similar kinase was present. Work on two cyclic AMP enzymes associated with the flight muscles of insects continued and it was shown that there are significant differences between the molecular properties of the grasshopper and locust enzymes.

A detailed study was made of the effects of various ion-pairing reagents in the reversed-phase HPLC behavior of the insect neurotransmitter proctolin and other related myogenic peptides. Solvent systems were identified which enabled the resolution of proctolin from pentapeptide analogues differing by only a single amino acid unit. Proctolin was also readily separated from its five possible diastereoisomers. Improvements were made in the isolation of proctolin and other myogenic peptides from the cockroach by chromatography on carboxymethyl cellulose. Homogenates of both the hindgut and foregut of the American cockroach were shown by ion-exchange chromatography, gel filtration, and electrophoresis to contain a wide spectrum of enzymes which hydrolyzed proctolin into physiologically inactive elements. HPLC analysis demonstrated that proctolin disappearance and the formation of arginine/tyrosine paralleled the loss of activity in the isolated hindgut. Three potential inhibitors of proctolin receptors were tested but all showed low activity.

Structure-activity studies on the uncoupling of oxidative phosphorylation in insects by several analogues of juvenile hormones (JH) was completed. The effective uncoupling concentration of JH I was reduced from about 400 nmol/mg protein to about 80 nmol/mg protein. All other analogues were found to be as active except for JH III, which continued to be about five times less effective as an uncoupling agent. Results indicated that uncoupling was initiated after a critical quantity had partitioned into the membrane. Replacement of the ester group by a carboxyl group did not alter potency but enhanced the onset time of uncoupling.

### Systemic fungicides

Ten new thiophene carboxamides were prepared, many of which showed high inhibitory activity to carbathiin-resistant mutant strains of corn smut. Good activity was also shown in vivo against a range of carbathiin-insensitive fungi including *Phycomycetes* sp. Highest activity was shown by 5-amino-3-methylthiophene-2-carboxanilide. The cooperative project with the University of California on the use of photoaffinity-labeled carboxamides yielded exciting results. Use of purified tritiated azido-carbathiin enabled the location and identification of the polypeptides responsible for carboxamide binding and

inhibitory activity in the succinate-ubiquinone reductase complex (II). The site of action of thenoyltrifluoroacetone was also identified since it competes with carboxamide binding. Thus, by use of this technique the site of action of the agriculturally important fungicide carbathiin (carboxin) has been established.

The macroscope measurements on the root system of corn was completed. This is probably the most comprehensive study of a single root system published to date. It was shown that 89% of the surface area resided in roots of 0.2 mm diam or less, these presumably being the roots mainly concerned in the uptake of systemic fungicides and nutrients. The inability of fine suspensions (gold sols) and protein solutions to suffuse throughout the xylem system indicated that barriers to free passage in the xylem are more numerous than previously recorded.

## ENVIRONMENTAL TOXICOLOGY

### Effects of pesticides on nontarget organisms

The assessment of the litter bag technique for analyzing pesticide effects in soil was virtually completed. Experiments using carbofuran with active ingredient at 11.2 kg/ha in a cornfield demonstrated that millipedes were an important factor in the corn leaf reduction process. The collection of soil arthropods was expanded from 2500 to 3300 slides and alcohol specimens. The majority of these specimens were identified as to genus and species with the help of the Biosystematics Research Institute. Thirty specimens were donated to the Canadian National Collection as new records for Canada or new species. A comprehensive basic study on the biology and fecundity of the manure worm, *E. foetida*, was completed.

Studies on the isolation and evaluation of thiram-resistant strains of *Rhizobium japonicum* showed that the nitrogen-fixing activities of 206 thiram-resistant cultures improved greatly using the rhizobial nuclear conjugation technique. The nitrogen-fixing activities of 218 isolates of nonsymbiotic nitrogen fixers in sandy soil were confirmed. Of particular interest was the observation that nitrogen fixation by some fungi and actinomycetes isolates was greater than that shown by bacterial cultures. A study on the microbial degradation of the newer pyrethroid insecticides in sterilized and fresh mineral and

organic soils showed no long-term effect of these materials on soil microbial populations. Significant difference in persistence of the pyrethroids between sterile and nonsterile soils was observed. The order of increasing resistance to microbial degradation in both soil types was fenpropanate, cypermethrin, permethrin, fenvalerate, and decamethrin. Some pyrethroids were found to have antimicrobial properties and the fungitoxicity of five pyrethroid insecticides against phytopathogenic fungi was determined.

Long-term studies carried out on herbicide-microflora interaction with paraquat showed the stimulation of cellulose degradation by low levels of the herbicide. It was shown that herbicide combinations were not additive in their effects on nontarget organisms, some combinations being synergistic and others inhibitory.

### Environmental studies

Studies on the persistence of organophosphorus and carbamate insecticides in organic soils showed that carbofuran, chlorpyrifos, fonofos, and chlorfenvinphos were all less persistent than ethion. Except for carbofuran, which did not persist to the end of the growing season, residues of the insecticides were carried over to the next year. Residues did not accumulate over a 3 yr period. Studies in the field and laboratory identified oftanol as a relatively persistent organophosphorus compound likely to be found in crops, especially when grown in sandy soils. The pyrethroid fenvalerate was shown to persist in an organic soil for over 2 yr.

Work on the relationship between insecticide solubility in water and its bioactivity in soil indicated that the more soluble the insecticide, the less active it was in soil. Using fensulfothion as a model compound predictions were made regarding the bioactivity of some of its derivatives based on solubility data. Preliminary results have been promising insofar as the relatively insoluble fensulfothion sulfide has been found to be very active in soil.

The effect of metal ions on the degradation (persistence) of parathion in soil showed that iron and its hydrolysis products degraded parathion to its oxon or to *p*-nitrophenol, or both. This effect was prevented by the presence of dissolved organic matter. Aluminum chloride did not degrade parathion under similar conditions. Work was completed on

the behavior of 12 insecticides in soil and aqueous suspensions of soil and sediment as well as their persistence in water. This work provided a basis for predicting the behavior and persistence of insecticides in the environment. A study of the microbial degradation of fensulfothion, parathion, and carbofuran by mixed cultures of soil organisms was completed. Fensulfothion and parathion were rapidly converted to metabolites under reducing conditions whereas carbofuran was stable under the same conditions.

The analyses of potatoes, onions, and turnips for 0.01 ppm of carbofuran and its metabolites by GC-MS with a selective ion monitor detector was not possible without clean-up, but suitable procedures were developed with minimum modification of the procedure developed for crude extracts of less difficult crops. The method was also adapted for the analysis of carbaryl residues in potatoes. The analytical reproducibility obtained by the GC-MS method permitted careful examination of the severe losses encountered by use of other analytical procedures. It was shown that carbofuran at the 0.01 ppm level is less stable to the acid-digestion procedure than suggested in published work. Procedures for the analysis of aldicarb, its sulfoxide, and sulfone in soil at the 0.1 ppm level were developed using HPLC. Carbofuran residues in treated farm soils were analyzed and persistence of granular carbofuran were compared with ethion and fonofos residues from seeding time to harvest. Results obtained helped to explain the lesser efficiency of carbofuran and its lack of persistence. A start was made on disposal of pesticides and their containers at the farm level. The retention of pesticides in unrinsed containers was determined.

### Pesticide toxicity and mode of action

Results obtained with methoxychlor, dicofol, and DDT indicated that these were general membrane poisons rather than specific neurotoxins as generally believed. The toxic effect was related to the fluidity of the lipid phase of the membrane and was supported by differences in behavior of the pesticides. Methoxychlor and DDT were shown to have a negligible effect on the movement of potassium ions across red blood cells where the lipid phase is rigid because of the high cholesterol content. Dicofol, by contrast, caused a significant increase in

permeability of the red blood cells to potassium.

Work on the general analysis of the kinetics of biological transport continued. The binding of molecules related to choline was explored in detail and led to a better understanding of the nature of substrate and inhibitor complexes with carriers. The experiments on this system, and a new analysis of an exchange transport system in mitochondria, showed that fundamentally different mechanisms are involved. The results obtained helped to achieve the aim of selectively disrupting transport in cell membranes by either reversible or irreversible agents.

Studies on insecticide-plant interaction showed that the carbamate insecticides carbaryl and carbofuran had different effects in corn and peas on the metabolism of indoleacetic acid (IAA) in vivo. Carbofuran and its metabolites had a similar effect to that of caffeic acid on the formation of bound IAA

and IAA degradation whereas carbaryl had a different effect. The results showed that the insecticides interfered with important metabolic processes which control growth and development of plants. Work with the important herbicide glyphosate showed different effects on chlorophyll synthesis and growth of plants under normal growing conditions, indicating a multiple inhibitory action in plants. The inhibition of plant growth in the dark or under light showed that glyphosate was capable of controlling vegetative growth both above and below ground. Tissue culture experiments established that different species of crop plants showed different degrees of tolerance for glyphosate. It was shown that IAA can partially reverse the glyphosate-induced inhibition, suggesting a possible interaction between glyphosate and the auxin-type herbicides, such as 2,4-D. Glyphosate was also shown to inhibit the biosynthesis of certain phenolic plant constituents.

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# Research Program Service

## Ottawa, Ontario

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Resigned 17 February 1979

Information Processing

J. F. PITON

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J. SHARKEY

Editing

Laid off 23 June 1979

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<sup>1</sup>Seconded to Managerial Accountability Directorate, 15 October 1979.

## INTRODUCTION

Research support provided by Research Program Service includes a wide range of scientific information, technical, and publication services to the Research Branch. During 1979 the Pesticide Information Liaison Section was reorganized to become the Scientific Information Retrieval Section with additional responsibility for the *Inventory of Canadian Agricultural Research* (ICAR). The 1978–1979 ICAR index was published for the Canadian Agriculture Research Council (CARC), as was the 1978 *Pesticide Research Report* and the 1979 *Research Branch Inventory*. Branch circular 79-5 was issued to inform all managers of publishing procedures for Branch manuscripts and all Branch publications are now monitored to ensure adherence to official language requirements.

Departmental representation on the Interdepartmental Committee on Air Surveys, Department of Energy, Mines, and Resources, for contract surveys of plant diseases and soil mapping was continued, as was the coordination of aerial research photography with the National Research Council. The timely release of the *Canadian Plant Disease Survey* was established and maintained during 1979 and a new publication, *Pesticide Information*, was introduced.

The coordination of several scientific missions to and from Canada was undertaken and the programs for operating and extramural research grants, visiting fellowships, and the Canada/France exchange program were administered.

This report is a summary of developments during 1979. Detailed information may be obtained by writing to: Director, Research Program Service, Research Branch, Ottawa, Ont. K1A 0C6.

R. Trottier  
Acting Director

## AWARDS AND BRANCH LIAISON

The administration of extramural research, operating grants, visiting fellowships, and scientific missions to and from Canada was continued during 1979.

The extramural research program is used to solicit specific research activities from university scientists to augment current research programs. The program is the responsibility of a departmental committee appointed by the Deputy Minister. In 1979 there were 72 applications received.

Operating grants are awarded to individual investigators, who must be staff members of Canadian universities, as contributions toward the normal operating costs of specific proposed research projects with definite implications of value to the agricultural industry. The selection committee consists of three representatives from Agriculture Canada and seven from faculties of agriculture and veterinary science. There were 311 applications received in 1979.

The visiting fellowship program gives promising young scientists, from all over the world, the opportunity to work with distinguished researchers in their respective fields before embarking on careers in scientific research. The program is administered by the Natural Sciences and Engineering Research Council on behalf of Canadian government departments and agencies. Research Program Service acts as liaison between the Council and Agriculture Canada. In 1979 there were 156 applications for fellowships in this department.

Eighteen scientific missions or visits to Canada during the past year included delegates from the USSR, People's Republic of China, Czechoslovakia, Israel, Sweden, Denmark, Brazil, Romania, Nigeria, Pakistan, and Korea. Canadian missions visited the USSR, Argentina, Chile, and Israel.

Nine visits to France and four from that country were conducted under the Canada/France scientific exchange program.

## GRAPHICS

Research photography and production art and illustration services to the Branch and other agencies within the Department continued to increase during 1979, with over 43 000 units produced during the year for an average of 132 requests for work per month. Services provided include photomicrography, laboratory and field technical photography, film and print processing, and color separation and lithographic processes, together with technical and biological illustration, publication layout and design, and chart, graph, and figure preparation for scientific journals.

Due to heavier demands for services during the year, contracted production increased by 125% over that in 1978 and a study of computerized production reporting was initiated to improve planning and control.

## SCIENTIFIC INFORMATION RETRIEVAL SECTION

Computerized national information storage and retrieval systems were maintained during 1979 on pesticides and on agricultural research.

The *Pesticide Research Report* editions from 1973 to 1979 were computerized and retrospective searches can now be made. Ten technical data sheets were released during the year on candidate pesticides prior to their experimental use in Canada. As a result of coordinating the minor use of pesticides program, data on 23 pesticides were processed and directed to Health and Welfare Canada and to the Pesticides Section, Food Production and Inspection Branch, for registration.

Commonwealth Institute of Biological Control contracts were coordinated and managed for Agriculture Canada and for the Canadian Forestry Service. In 1979, 17 shipments were received from eight countries for a total of

19 066 specimens. Thirty-nine shipments were sent to research establishments; 14 parasite species totaling 12 685 insects were sent to seven provinces for study or release, or both.

The Inventory of Canadian Agricultural Research, listing 4050 projects from 145 research establishments, was completely updated. Seventy requests for agricultural research information were received during 1979 with an average turnaround time of 3 wk. The Service participated in the expert committee meeting on current research information systems, held by the Organization for Economic Cooperation and Development (OECD) in Paris, and a CARC informational brochure to promulgate ICAR was published.

## SCIENTIFIC EDITING/TEXT PROCESSING

Editorial and word processing services were provided for scientific and technical publications of the Branch and the Department to help meet the technology transfer requirements of the Research Branch. In 1979, 44 English and 41 French manuscripts were edited, comprising over 7900 pages and covering a wide range of agricultural subjects. While many of the publications were of interest to the public, scientific texts were directed at research workers in universities, industry, and government.

Two major books were published during the year: *Budd's Flora of the Canadian Prairie Provinces* and *The Mosquitoes of Canada*, Part 6 in the series *The Insects and Arachnids of Canada*. To assist Branch authors in the submission of manuscripts, the bulletin *Guidelines for Preparing Manuscripts* was written and published in 1979.

To reduce editorial and production times editing of some manuscripts was contracted out and 3000 pages were processed by the use of computer facilities.

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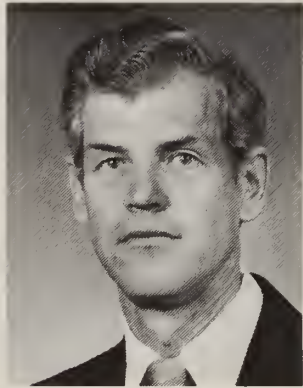




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## PREFACE

The Western Region, with Headquarters in Saskatoon, consists of 15 research stations, four experimental farms, and eight substations. These research establishments serve the agricultural community throughout the Prairie Provinces and British Columbia. In 1979 the Region managed a budget of \$39 million and employed approximately 340 professionals in implementing its programs.

Plant breeding research culminated in licensing 13 cultivars, including two varieties of spring wheat, two barleys, two oats, one fall rye, two wheatgrasses, three legumes, and one pea. Two corn hybrids and a sunflower hybrid were also released.

Research in agronomy showed that continuous cropping with cereals, perennial forage, and watershed management were effective in reducing dryland soil salinity. Zero tillage resulted in cereal yields on stubble equal or superior to those obtained with conventional tillage. Two new herbicides were identified as superior to existing compounds for control of broad-leaved weeds, and an effective low-cost control for grasshoppers using a bran bait treated with dimethoate was demonstrated.

Beef cattle research was conducted at seven of the 15 stations in the Region and included studies on breeding, nutrition and forage utilization, and management. Advances were recorded in improved efficiency of feed utilization with brome-alfalfa hay harvested at 20% moisture and stored under shelter compared with the same hay harvested at higher moisture content and stored outside; a four-fold increase in forage dry matter production with improved cultivated grass species compared with seeded native grasses; elimination of mold growth by treatment of hay with 2% ammonia in forage preservation studies; and control of stem eyespot of fescue with the fungicide Biloxazol.

Corn silage of higher dry matter and higher grain content resulted in increased milk production in dairy cattle nutrition. In swine nutrition research, rapeseed meal from new double low cultivars was used to completely replace soybean meal in rations for growing and finishing without adverse effects on performance.

Horticulture research was conducted at seven stations. Important achievements included confirmation that the apple mealybug is a vector in little cherry disease; development of an optimum growth culture for pear meristem cultures; and discovery of a new proliferation technique for rapid propagation of grape accessions.

Research on food quality and processing technology is important in the Region. An efficient dehydrator for producing fruit leather was designed and made available to industry. A new energy-saving method for making brown sugars was developed, and a process for desalting and canning brined mushrooms was devised.

The meat research program is integrated but broadly based, incorporating studies of quality, biochemistry, microbiology, and preservation technology. A national hog carcass and pork quality study was completed.

There were several significant staff changes within the Region in 1979, including two retirements. Dr. W. C. (Bill) McDonald retired as Director of the Winnipeg Research Station after serving 30 yr with the Department. The other retirement was that of Dr. J. E. R. (Ross) Greenshields, Director of the Research Station at Saskatoon, who also served 30 yr with Agriculture Canada. Other changes include the transfer of Dr. F. K. (Fred) Kristjansson from the Research Station at Lacombe to the position of Research Coordinator for Animals, Branch Headquarters, Ottawa. Mr. H. C. (Hans) Korven joined the staff of Western Region Headquarters in 1979 as Contracts Specialist. A second addition to Headquarters staff was Dr. B. H. (Bernie) Sonntag, who took up the position of Economist.

Further information about our programs may be obtained by writing to the research establishments concerned or by addressing inquiries to Western Region Headquarters, Research Branch, Agriculture Canada, Room 600 Federal Building, 101-22nd Street East, P.O. Box 9241, Saskatoon, Sask. S7K 3X5.

A. A. Guitard

## PRÉFACE

La région de l'Ouest, dont l'administration centrale est à Saskatoon, compte 15 stations de recherches, quatre fermes expérimentales et huit sous-stations. Ces établissements desservent la collectivité agricole des provinces des Prairies et de la Colombie-Britannique. En 1979, son budget était de 39 millions de dollars et son personnel d'environ 340 chercheurs.

Les projets de recherche qui portent sur le croisement des plantes ont permis de faire homologuer cette année 13 nouveaux cultivars, soit deux variétés de blé du printemps, deux variétés d'orge, deux variétés d'avoine, deux variétés de seigle d'automne, deux variétés de chiendent, trois variétés de légumineuses et une variété de pois. On a aussi fait homologuer deux hybrides de maïs et un hybride de tournesol.

Les recherches en agronomie ont démontré que la mise en culture continue, le fourrage vivace et la gestion de l'écoulement des eaux sont efficaces pour réduire la salinité des sols secs. On a aussi fait la preuve que la culture sans labour sur chaume donnait des rendements céréaliers égaux ou supérieurs à ceux obtenus par les techniques de travail sur sols classiques. On a trouvé deux nouveaux herbicides supérieurs aux composés actuellement utilisés pour combattre les mauvaises herbes dicotylédones. D'autre part, un appât au son traité au diméthoate s'est révélé un moyen économique et efficace pour combattre les sauterelles.

La recherche sur le bovin de boucherie intéresse sept des 15 stations. Des études portent sur la reproduction, la manutention du fourrage, la nutrition et la conduite des troupeaux. On a enregistré un gain dans la valorisation des aliments par les bovins de boucherie grâce à l'association brome-luzerne récoltée à 20% d'humidité et entreposée sous abri en comparaison avec le brome-luzerne récolté à un taux d'humidité plus élevé et entreposé sans abri; on a quadruplé la production de matière sèche des fourrages en employant des espèces améliorées de graminées cultivées au lieu de semis de graminées indigènes. On a enrayé la croissance des moisissures dans le foin humide par traitement avec une solution d'ammoniac à 20%. Enfin, on a découvert un moyen de combattre la tache ocellée de la tige de la fétuque par le fongicide Biloxazol.

Du côté de la nutrition des bovins laitiers, on a mis au point un ensilage de maïs contenant un plus grand taux de matière sèche et de grain ce qui

permet d'accroître la production laitière. Les chercheurs en nutrition des porcs ont réalisé un nouveau tourteau de colza que l'on peut substituer au tourteau de soja sans nuire à leurs performances de croissance et de finition.

La recherche horticole est menée à sept stations. Il faut mentionner à son crédit la confirmation du rôle de la cochenille du pommier comme vecteur de la maladie de la petite cerise, la mise au point d'un milieu de croissance optimale pour la culture des méristèmes de poirier et la découverte d'une technique efficace pour la multiplication rapide de toutes les obtentions de vignes à l'essai.

La recherche sur la qualité alimentaire et les techniques de transformation est importante dans l'Ouest. On a réalisé la conception d'un déshydrateur très efficace pour la production de pâte de fruit déshydraté et on l'utilise maintenant dans l'industrie. On a aussi mis au point une nouvelle méthode économique d'énergie pour la fabrication de cassonade et un processus nouveau pour dessaler les champignons saumurés et les mettre en conserve.

Le programme sur les viandes est intégré mais comprend un large éventail d'activités en biochimie, en microbiologie, en études sur la qualité et en techniques de préservation.

En 1979, la région a connu quelques changements importants de personnel, dont deux départs pour la retraite. Ce sont M. W.C. (Bill) McDonald, l'ancien directeur de la station de recherches à Winnipeg, après 30 années de service au Ministère et M. J.E.R. (Ross) Greenshields, ancien directeur de la station de recherches à Saskatoon, après le même laps de temps dans notre ministère. Parmi les autres changements, il y a eu la mutation de M. F.K. (Fred) Kristjansson de la station de recherches à Lacombe au poste de coordonnateur de la recherche pour l'administration centrale (biosystématique) à Ottawa. Sont venus grossir l'effectif de l'administration centrale de la région de l'ouest MM. H.C. (Hans) Kørven à titre de spécialiste en travaux contractuels et B.H. (Bernie) Sonntag, économiste.

On peut obtenir de plus amples renseignements sur nos programmes en écrivant aux établissements de recherches concernés ou en s'adressant à l'Administration centrale de la région de l'Ouest, Direction de la recherche, Agriculture Canada, Édifice fédéral, pièce 600, 101. 22 rue Est, C.P. 9241, Saskatoon (Sask.), S7K 3X5.

A.A. Guitard



# Research Station

## Brandon, Manitoba

### PROFESSIONAL STAFF

W. N. MACNAUGHTON, B.Sc., M.Sc., Ph.D.	Director
A. J. DAGENAI	Administrative Officer
A. P. PILOSKI, B.S.A.	Information Officer

### Animal Science

J. H. STRAIN, B.S.A., M.Sc., Ph.D.	Head of Section; Animal breeding and management
R. L. CLIPLEF, B.Sc., M.Sc., Ph.D.	Meats physiology
G. W. DYCK, B.S.A., M.Sc., Ph.D.	Reproductive physiology
R. R. GRANDHI, B.V.Sc., M.Sc., Ph.D.	Swine nutrition
D. L. GRINWICH, B.Sc., M.Sc., Ph.D.	Reproductive physiology
G. W. RAHNEFELD, B.Sc., M.Sc., Ph.D.	Beef cattle genetics

### Plant Science

L. D. BAILEY, B.S.A., M.Sc., Ph.D.	Head of Section; Soil-plant relationships
K. W. CAMPBELL, B.Sc., Ph.D.	Barley breeding
P. N. P. CHOW, <sup>1</sup> B.S.A., M.A., Ph.D.	Weed physiology
R. D. DRYDEN, <sup>2</sup> B.S.A., M.Sc.	Crop culture
R. I. HAMILTON, <sup>3</sup> B.Sc., M.S.A., Ph.D.	Corn physiology
E. D. SPRATT, B.S.A., M.Sc., Ph.D.	Plant nutrition
R. I. WOLFE, B.S.A., B.D., Ph.D.	Barley breeding

## Departures

A. T. H. GROSS, B.S.A., M.Sc.  
Deceased June 1979

Forage crops

A. R. MCELROY, B.Sc., M.Sc.

Corn-soybean physiology

Transferred to Ottawa Research Station, Ottawa,  
September 1979

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<sup>1</sup>On postdoctoral transfer of work to Weed Research Organization, Oxford, England, September 1979.

<sup>2</sup>On secondment to CIDA, Canada-Sri Lanka rainfed agriculture project.

<sup>3</sup>Returned 1 September 1979 from 2 yr assignment to CIDA, on Canada India dryland project.



## INTRODUCTION

Research continues to place emphasis on breeding of beef cattle; breeding, physiology, nutrition, and management of swine; and soil fertility, plant nutrition, cultural practices, and weed control of cereal and oilseed crops.

It is with regret that we record the death in June 1979 of Mr. A. T. H. (Hugo) Gross who served Agriculture Canada faithfully and well for 27 yr. He was well recognized across Canada for his research with forage crops.

Bedford, a new feed barley cultivar with improved kernel weight and straw strength, which outyields Klondike by 8% in the eastern Prairies, was licensed.

The newly licensed soybean cultivar, Maple Presto, developed in cooperation with the Ottawa Research Station, represents a breakthrough in early maturity and has provided a new standard for earliness in the crop. Maple Presto matures 10–14 days earlier than Portage, the previous early standard in Manitoba.

The discovery that placement of fertilizer P directly below the seed significantly increased yields of flax, rapeseed, and soybeans was a significant advance in methods of fertilizer P application.

This report summarizes only the main results of research in 1979. More detailed results and reprints of published papers may be obtained from: Research Station, Research Branch, Agriculture Canada, Box 610, Brandon, Man. R7A 5Z7.

W. N. MacNaughton  
Director

## ANIMAL SCIENCE

### Beef cattle

*Cow's body weight and effects on calf's preweaning traits.* Over a 9 yr period, 635 birth weights and 607 weaning weights of shorthorn calves were analyzed and revealed sex of the calf as the most important source of variation in birth weight, weaning weight, and preweaning average daily gain. The heaviest cows in June, October, and December prior to parturition and at parturition produced the heaviest calves at birth, but the cows that maintained their weight throughout gestation and subsequent lactation produced the calves which grew more rapidly and were heavier at weaning. There was no apparent effect of cow weight change before or after parturition on other preweaning traits. Correlations of birth weight with weaning weight, preweaning average daily gain, and cow weight at parturition were  $0.56 \pm 0.03$ ,  $0.43 \pm 0.04$ , and  $0.24 \pm 0.04$ , respectively. Correlations of weaning weight and preweaning average daily gain with cow weight at parturition were  $0.42 \pm 0.04$  and  $0.40 \pm 0.040$ .

*Time of day of parturition in beef cows.* In the station herd over a 4 yr period the hourly distribution of 1151 calvings was relatively

uniform. Year of calving, sex of calf, age of cow, weight of cow, and calf birth weight had no influence on the time of calving. Only the breed of maternal grandsire and maternal granddam, for some unexplained reason, affected the time of calving, with 59, 54, 51, and 46% of the calves having Hereford, Charolais, Simmental, and Limousin grandsires, respectively, and 56, 56, and 41% of the calves from Hereford, Angus, and Shorthorn granddams, respectively, being born during the day (7 a.m. – 7 p.m.).

The relationship between hour of feeding (8–9 a.m. and 3–4 p.m. versus 11–12 a.m. and 9–10 p.m.) and time of calving (day versus night) was studied in a cooperating purebred herd (104 cows). Preliminary results show that on the normal feeding regime, 38% of the parturition occurred during the daytime period compared with 80% for the cows on the experimental feeding regime (11 a.m. – 12 a.m. and 9 p.m. – 10 p.m.).

### Swine

*Factors affecting the incidence of postlactational anestrus in the sow.* In two experiments with 87 postlactational Lacombe sows, anesthesia on day of weaning, wake up at 8 p.m., pair confinement, pair confinement with wake up every 6 h, and outside housing had

no effect on the number of sows returning to estrus nor on the interval from weaning to estrus (approximately 5 days).

In a third experiment 45 para 1 and para 2 postlactational Lacombe sows were treated with a blank silastic implant or a progesterone implant (200 mg) in the ear for 48 h after weaning. The percentage of sows returning to estrus was the same for both treatments. The interval between weaning and estrus was  $7.0 \pm 0.6$  and  $6.9 \pm 0.6$  days, respectively, for blank and progesterone implanted sows that had returned to estrus within 15 days. This interval was 2 days longer for para 1 sows than for para 2 ( $8.0 \pm 0.5$  versus  $6.0 \pm 0.5$ ). Among the sows that became pregnant, the progesterone implant had no effect on uterine weight (P— $1577 \pm 71$  g versus C— $1460 \pm 44$  g), ovarian weight ( $16.2 \pm 0.7$  g versus  $15.7 \pm 0.5$  g), number of embryos ( $12.9 \pm 0.8$  versus  $11.4 \pm 0.6$ ), or percent embryo survival ( $76.9 \pm 4.0\%$ ,  $79.8 \pm 4.0\%$ ) but did increase ovulation rate ( $16.3 \pm 0.6$  CL,  $14.4 \pm 0.6$  CL). Parity effects in the pregnant animals were evident only for ovarian weight (para 1 —  $14.9 \pm 0.7$  g, para 2 —  $17.1 \pm 0.4$  g) and ovulation rates (para 1 —  $13.8 \pm 0.5$ , para 2 —  $16.6 \pm 0.6$  CL).

*Effect of estrone and progesterone on embryo survival.* Embryo survival at 25 days of pregnancy (day 25) in Yorkshire and Lacombe gilts was improved by daily injections of estrone ( $12.5 \mu\text{g}$ ), but not by progesterone (25.0 mg) or progesterone plus estrone from day 14 to day 21. Identical treatment of Yorkshire sows did not affect embryo survival at day 25 but implanting with silastic implants containing estrone at day 14 for 7 days significantly improved embryo survival at 60 and 90 days of pregnancy. These results suggest that embryonic losses occur earlier in gilts than in sows and that litter size can be increased by estrone supplementation during this critical period of gestation.

*The effects of testosterone and  $5\alpha$ -androstenedione immunization on sex odor and growth in swine.* Barrows implanted with testosterone gained faster over a 10 wk period than untreated barrows, gilts, testosterone implanted boars, untreated boars, and boars immunized with  $5\alpha$ -androstenedione but carried more back fat than all other groups except the untreated barrows. Boars immunized with  $5\alpha$ -androstenedione grew the slowest and were the leanest of all groups. A trained sensory

panel was unable to detect any differences among groups in the sex odor in fat samples taken at slaughter (90 kg) or by biopsy 2 wk prior to slaughter. Radioimmunoassays are under way to quantify  $5\alpha$ -androstenedione levels in blood and fat samples.

*Halothane tests in the swine herd.* To evaluate the Halothane method for identification of pigs susceptible to porcine stress syndrome (PSS), 230 Yorkshire and Lacombe barrows were subjected to 5% halothane and oxygen for a 3 min period. No reaction was observed in most cases, but various degrees of reaction, from minor to extreme, were noted in 5% of the pigs. Blood samples from the reacting pigs are being analyzed for creatine phosphokinase activity. Muscle quality as indicated by postmortem muscle pH and color development is being monitored.

*Efficient use of pen space for market hogs.* Two penning systems (a) conventional with a constant pen space ( $0.84 \text{ m}^2$  per pig) from start to finish and (b) modified with varying pen space (0.28, 0.56, and  $0.84 \text{ m}^2$  per pig) and varying number of pigs (24, 12, and 8 per pen) from start to 30 kg, from 30 kg to 60 kg, and from 60 kg to market weight were compared to study their effect on growth performance of market hogs. Although the modified system significantly reduced growth rate and feed efficiency of both Lacombe and Yorkshires during the early growing period, a compensatory increase in growth rate was observed in the latter part of the growth period. The growth performance was, however, less affected during winter than in summer. The modified system made it possible to raise approximately 25% more pigs in equal facilities and to empty the pens more quickly because of sorting into groups of uniform-size pigs.

*Nutrition and management to reduce age at sexual maturity in gilts.* In comparison to the regular 14% finisher diet, feeding a low-protein (11%) diet supplemented with amino acid lysine (0.3%) from 65 kg liveweight did not significantly affect the growth rate, feed efficiency, or age at sexual maturity. Management treatments such as physical exercise, mild electric shock, boar odor spray at weekly intervals, and constant exposure to a boar did not significantly reduce the age at puberty. However, mild electric shock treatment caused a considerable reduction of age at sexual maturity ( $213 \pm 11$  versus  $186 \pm 9$

days) in both Lacombe and Yorkshire gilts and this response was similar in both dietary groups.

## PLANT SCIENCE

### Cereal crops

*Wheat production and soil fertility.* A regression equation relating grain protein to percent N in the plant at the flag-leaf stage was developed from Indian Head Experimental Farm data from a long-term crop rotation study. This equation can be used to predict the need for urea sprays to increase protein in the grain.

A comparison of wheat and flax production on various soil types indicated that subsoil calcium:magnesium ratios of  $>1$  did not affect wheat yields but did depress flax yields.

*Weed control in wheat.* A new experimental formulation, DPX 4189, controlled most broad-leaved weeds except wild buckwheat, with good crop tolerance. Wild oat control was not affected when DPX 4189 was applied in mixtures with difenzoquat and barban, but the wild oat control was reduced in mixtures with diclofop-methyl (Hoegrass) and flumetop-methyl. Separate applications of the latter with DPX 4189 gave no antagonistic effects. SSH 0860 gave wild oats control equal to triallate (Avadex) plus chloramben and gave control of some broad-leaved weeds. Mixtures of triallate and chloramben controlled wild oats, green foxtail, and some broad-leaved weeds, with good crop tolerance.

*Barley breeding and genetics.* A new feed barley cultivar, Bedford, was licensed in 1979. It has improved yield (8%) over Klondike in eastern and central Manitoba and has improved kernel weight, test weight, and straw strength. The variety was named in honor of Dr. S. A. Bedford, the first superintendent of the Brandon Experimental Farm and a prominent scientist and citizen. Advanced breeding lines from Brandon continue among top entries in the Western Cooperative Test, ranking 1, 2, and 5 in yield, and continue to have improved disease resistance and agronomic performance.

In malting barley, one advanced line (BT342) continues to perform well in the Western Cooperative Test, having improved malting quality over Bonanza. Three additional lines, all with improved malting quality and yield over Bonanza, are scheduled for

advancement to the Western Cooperative Test in 1980. A new full-scale yield test of two-row lines developed at Brandon was conducted, and several promising lines were identified. Malting quality, disease resistance, and agronomic performance of lines developed using the double haploid technique indicate that this method has good potential for barley research and breeding, particularly in wide crosses.

*Barley production and management.* The protein content of barley was significantly increased when grown after sweetclover, soybeans, or fababeans compared with fallow or on barley stubble with N at 60 kg/ha. Barley on fallow outyielded barley following the legumes, but the highest yield was obtained when barley was grown after the legumes with N at 60 kg/ha.

*Corn physiology and management.* Climatic conditions approximated those of 1974, and evaluation of lines under these 'test' conditions show that yields were significantly improved over those obtained in 1974. The yield formula, based on planting date and developed at Brandon, proved reliable in predicting a 30% reduction in yield and a 7% reduction in test weight of corn due to late seeding.

*Weed control in corn.* Herbicides are evaluated for their ability to control broad-leaved and grassy weeds and for low soil and crop residue. Soil-incorporated EPTC/R25778 (Eradicane) and butylate, supplemented by postapplied dicamba/2,4-D/mecoprop, gave the best total weed control. Pyridate/atrazine, dicamba, and dicamba/2,4-D gave good control of broad-leaved weeds but little control of green foxtail. Corn was very sensitive to a mixture of ethylfluralin and atrazine.

### Oilseed crops

*Tolerance of rapeseed, flax, and soybean to drought.* Rapeseed (0–1120 kg/ha) yielded less than either flax (635–1305 kg/ha) or soybeans (1091–2200 kg/ha) under the high temperature – low rainfall conditions that followed the late cool spring of 1979.

*Fertilizer placement for rapeseed, flax, and soybeans.* The degree of response of these crops to fertilizer P was related to the quantity of fertilizer and its placement in relationship to the seed. Banding gave significantly higher yields than either spring or fall broadcast P. Placement 2.5 cm directly below

the seed was superior to banding 2.5 cm to the side and 2.5 cm below. Application with the seed was less effective than either of the other two banding methods.

*Soybean physiology and management.* Nitrogen residue following soybean and faba-bean production was not sufficient to supply the requirements for a succeeding barley crop. When beans were harvested at maturity, N at 60 kg/ha was required to maximize yield of barley. However, when the crops were plowed in as green manure, N at only 30 kg/ha was required. On all treatments, protein content of barley was higher than that obtained on barley stubble or summerfallow.

The new variety, Maple Presto, supported by the Brandon data, was licensed. The variety represents the earliest, nonshattering variety licensed for commercial production. It matures about 10–14 days earlier than the variety Portage and was equivalent in yield and protein tests. Currently several advanced lines, related to Maple Presto and originating from the Ottawa Research Station breeding program, show significant yield increases over Maple Presto with only marginal increases in the number of days to maturity.

*Weed control in rapeseed, flax, and soybeans.* In rapeseed, EL 5261, a short-residue-life formulation, gave better weed control than trifluralin. Excellent control of wild oats and volunteer barley was obtained with BAS 9052, while Hoegrass controlled volunteer corn.

In flax excellent weed control was obtained with triallate, trifluralin, and ethylfluralin. BAS 9052 alone and in mixtures with MCPA amine, MCPA K, and propanil gave good control of wild oats and broad-leaved weeds without injurious effects on the crop.

In soybeans excellent grassy and broad-leaved weed control continues with preplant soil incorporated trifluralin followed by a postemergence application of bentazon or RH 6201. BAS 9052 with a wetting agent gave good control of wild oats, while a mixture of trifluralin and metribuzin controlled wild oats

and lamb's-quarters. The new variety Maple Presto had good tolerance to these herbicides.

### Forage crops

*Alfalfa production and management.* Both K and S applied to established stands of alfalfa not only increased yield and protein content, but reduced the soluble protein fraction. This fraction, among other factors in alfalfa, has been implicated as contributing to the bloat problem.

A three-cut system of management has been developed for alfalfa; the net effect is to produce increased yield of high-protein forage. The crop is harvested at full-bud to 5% bloom stage, when crude protein content is approximately 20–24% and the yield is approximately 90–95% of maximum.

*Production and management of grasses.* Old grass stands are less responsive to fertilizer N than new stands. Chemical analysis of 30 cm<sup>3</sup> biomass samples taken from old grass swards show that 30–35% of the annually applied N was immobilized by the soil biomass. This N, apparently, is not available to the grass sward, but upon breaking, slowly mineralizes and is available to subsequent crops.

*Grass-legume mixtures for hay and pasture.* Brome-alfalfa mixtures seeded either in the same row or in separate rows at right angles continue to produce the highest yields. In these stands all varieties of grasses seeded with several forage legumes continue to survive but the legume component suffers serious winter injury. After 5 yr losses from winterkill were: Leo birdsfoot trefoil >98%; Melrose sainfoin >80%; Vernal alfalfa 15%; Rambler alfalfa <10%.

*Weed control in forage crops.* Good control of wild oats and green foxtail in seedling alfalfa was obtained with asulam. Mixing the chemical with 2,4-DB gave good control of stinkweed and wild mustard, with only slight crop damage. Similar results were obtained with BAS 9052/2,4-DB mixtures. However, mixtures of bromoxynil and asulam or BAS 9052 seriously injured alfalfa seedlings.

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New crops  
Management, breeding of  
ornamentals

### Departures

D. G. DORRELL, B.S.A., M.Sc., Ph.D.  
On leave of absence

Oilseed quality

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Resigned December 1979

New crops



## INTRODUCTION

The program of the Research Station at Morden is directed toward improving cultivars and management practices in buckwheat, field corn, field peas, flax, sunflower, potatoes, herbaceous and woody ornamentals, and new crops.

We welcome Dr. G. H. Friesen who transferred from Harrow to conduct research on weed control in special and new crops. Dr. M. D. Stauffer resigned from the New Crops program in December 1979.

This report highlights some of the more important research results from the station in 1979. Further information can be obtained by personal communication with the scientists at the Research Station, Agriculture Canada, P.O. Box 3001, Morden, Man. R0G 1J0.

B. B. Chubey  
Acting Director

### FIELD CROPS

#### Buckwheat

*Breeding.* CM 136, a large-seeded selection, which has outyielded Mancan by 9.5% in 4 yr of testing, will be proposed for licensing. It is expected to replace Mancan, presently grown on approximately 80% of the commercial buckwheat cropland in Manitoba. Promising large-seeded, semidwarf lines were placed in replicated trials. Selections for increased seed set are being made as presently licensed cultivars set less than 12%.

*Management.* No beneficial effects on yields were found from foliar applications of  $H_3BO_3$ ,  $CaCl_2 \cdot 2H_2O$  applied to buckwheat during the flowering and seed stages in a 3 yr study. Thus, no advantage can be expected from foliar applications to buckwheat grown on soils containing an adequate supply of boron and calcium.

*Disease.* In 21 fields sampled in a province-wide survey, downy mildew was found in all fields with 70–100% of the plants being infected. Damage from this disease was light in 1979, probably due to the low rainfall. Resistance to this disease was found in several breeding lines.

*Weed control.* Satisfactory tolerance was noted with the grass control herbicides diclofop, methyl, difenzoquat, TCA, napropamide, triallate, EPTC, alachlor, metolachlor, and dinitramine.

#### Field corn

*Breeding.* Several new hybrids were released to the seed trade for multiplication and further evaluation. Their maturities, stalk qualities, and yields were outstanding. The relative maturity of hybrids at flowering time was maintained until harvest time in 65% of the hybrids licensed for sale in Manitoba.

Two inbreds have been identified as fast driers when crossed with several European flint inbreds. This suggests that European flints will soon appear as parents of early-maturing hybrids for Western Canada. Early versions of the Elite corn belt inbreds A619, H99, and Mo17 are in the fourth generation of inbreeding following one backcross to the Elite parent. Some of these selections resemble their respective Elite parents quite closely and are up to 20 days earlier in flowering.

*Weed control.* Postemergence applications of bromoxynil, bentazon, cyanazine, and dicamba/2,4-D controlled broad-leaved weeds with adequate crop safety. Preplanting soil-incorporated treatments of metolachlor/atrazine, EPTC<sup>+</sup>/atrazine, or pendimethalin controlled green foxtail and wild oats. MCPA, alone or in mixture, caused severe injury to corn.

#### Field peas

*Breeding.* Lenca, a yellow-seeded cultivar, was licensed in 1979 and pedigreed seed released to growers through SeCan. This cultivar outyielded standard cultivars by 19–25% in Eastern Canada. Three selections of green-seeded field peas were made in 1979 which have superior green color and less bleaching than Triumph. Preliminary seed

increases have been established for these selections. A number of leafless pea lines were selected which outyielded Century or Trapper and have similar seed size.

*Management.* Applications of nitrogen at 22, 34, and 45 kg/ha increased yields of leafless peas, with the highest yield being obtained with 45 kg/ha. There was no response to phosphorus fertilizer at similar rates. Semileafless peas at 800 000 plants per hectare outyielded plant population levels of 600 000 or 500 000.

*Quality.* Tests on cooking quality indicated that irrigation and application of phosphorus fertilizer improved cooking quality while nitrogen fertilizer tended to reduce quality. Early harvest also produced good cookers. Good cooking peas always contained a smaller amount of Mg in relation to P and K in the protein bodies.

*Diseases.* A total of 2451 breeding lines were evaluated for the presence of pea seed-borne mosaic virus (PSbMV). Of these, 212 lines showed virus infection. Thirty-six advanced breeding lines were assessed for reaction to *Mycosphaerella pinodes*. Most were found to be susceptible, some were intermediate, and one line (PI 272157) appeared to be resistant. Commercial seed treatment types of fungicide (captan, thiram, and benomyl) improved plant emergence and yields of commercial pea cultivars.

*Weed control.* Excellent control of redroot pigweed, lamb's-quarters, wild mustard, and green foxtail was obtained with sequential treatments of dinitroaniline types of herbicide followed by MCPB/MCPA, bentazon, or MCPA. Postemergence treatments of diclofop methyl or TCA followed 4 days later by metribuzin, bentazon, or MCPB/MCPA were equally effective.

## OILSEED CROPS

### Flax

*Breeding.* In over 3 yr of testing, FP 692 has outyielded Dufferin by 6% and is resistant lodging. FP 698, an early line, has outyielded Linott and Dufferin by 10% and 4%, respectively. Three other early lines outyielded Linott by 10% and had more oil.

*Diseases.* Field and greenhouse data reconfirmed that the level of postseedling rust

resistance (PSRR) is high in Norland and Noralta, moderate in Redwood 65, low in Nored, and not discernible in Summit. In field plots, yield losses due to rust were 22% and 30% in Nored and Summit, whereas losses were negligible in cultivars of high to moderate PSRR.

*Management.* The effectiveness of diquat as a preharvest desiccant for flax was determined. In most cases, the leaves, capsules, and at least the top 30% of the stem was dried, and this was considered adequate for straight combining. A rate to supply the active ingredient at 0.28 kg/ha generally was adequate, but rates up to 0.56 kg/ha may be required where growth of crop or weeds is heavy, or where faster and more complete drying is desired. Spraying should be delayed until normal swathing time, or possibly slightly later.

*Weed control.* EPTC and triallate were the most effective preplanting soil-incorporated herbicides for the control of wild oats. EPTC, metolachlor, and AC 206784 controlled green foxtail but thorough soil incorporation was essential. Effective postemergence herbicides were TCA, asulam, propanil, and BAS 9052. Bentazon, bromoxynil, linuron, picloram/MCPA, and DPX 4189 were the most selective herbicides for the control of redroot pigweed, lamb's-quarters, and wild mustard. Linuron/diclofop methyl (tank mixed) controlled all broad-leaved and grass types of weeds.

### Sunflower

*Breeding.* Sunflower hybrid CMH 101, licensed in 1979, is higher in oil content and earlier in maturity than most U.S. hybrids. Two experimental hybrids, in the cooperative tests for the first time, were higher yielding and earlier maturing than CMH 101. Germ plasm derived from interspecific crosses of cultivated *Helianthus annuus* and three wild *Helianthus* species has been released as a possible alternate source of cytoplasmic male sterility. Krasnodarets converted to the restorer and cytoplasmic male sterile form has been released to breeders as breeding material.

*Management.* Seeding on 18 June resulted in a 32% reduction in yield compared to seeding on 25 May. Yield increased slightly as the population density was increased from 30 000 to 60 000 plants per hectare. Diquat

applied as a preharvest desiccant when the seed moisture content was higher than 45% resulted in a reduction in yield and oil content.

*Diseases.* *Coniothyrium minitans*, the biological control agent of *Sclerotinia sclerotiorum*, on agar medium grew rapidly at 22°C and slowly at 10°C. However, growth rate varied greatly among isolates.

Thirteen percent of sclerotia from diseased sunflower heads were "abnormal," showing reduced infectivity, and were morphologically distinct. Several female lines were resistant to two or three diseases (rust, verticillium wilt, and downy mildew). Two inbred lines were found to be resistant to sclerotinia wilt.

*Weed control.* Wild oats left growing in hybrid 894 for 3 wk after crop emergence did not significantly reduce yields, although sunflower vigor was visibly reduced early in the season. The compounds BAS 9052 and KK-80 gave promise as postemergence selective herbicides for control of wild oats, green foxtail, and volunteer grain. Preemergence treatments with mixtures of triallate and dinitroanilines or chloramben appeared promising for control of wild oats, foxtail species, and some broad-leaved weeds, but required effective incorporation.

## HORTICULTURAL CROPS

### Ornamental crops

*Breeding.* Roses in the Parkland series have been named for release in the spring of 1980 through the Canadian Ornamental Plant Foundation. Morden Cardinette, a complex hybrid, is a dwarf everblooming type with cardinal red (RHS 53B) flowers. It has excellent potential as a pot plant for spring sale and later transplanting to gardens. Morden Centennial, a disease-resistant hybrid of Prairie Princess × [White Bouquet × (J.W. Fargo × Assiniboine)] is a vigorous everblooming rose suited for use as a bedding plant.

Promising selections of trees and shrubs being increased include hybrid ash from crosses between *Fraxinus nigra* and *F. mandshurica*, dwarf globe-shaped honeysuckles with greater hardiness than existing standards, silver-foliaged pyramidal poplars with increased hardiness, prairie-hardy weeping willows, and a vigorous-growing Japanese elm.

Four chrysanthemum selections were advanced for final evaluation and selections of penstemon, monarda, and lilies were increased for testing. A hybrid lily seedling was given the Hornback's Award from the North American Lily Show for the lily showing the greatest advance in hybridization.

*Arboretum and evaluation.* Evaluations were continued with the 3200 entries in the Morden arboretum. One hundred and eighty-nine additional accessions were received as seeds, cuttings, or plants; 10 entries were added to the Merit Trial. Winter damage to evergreens, particularly arborvitae and juniper, was assessed following the severe winter of 1978–1979. A major survey of fire blight was conducted on *Rosaceae* trees and shrubs at the Morden Research Station and at 629 residential lots in southern Manitoba.

*Propagation.* Propagation by leaf-bud cuttings of the newly named Morden Cardinette rose proved satisfactory for rapid plant increase and a production guideline has been prepared for pot culture. Bud take was slightly lower for chip-budding than for T-budding in apple, linden, hackberry, and Japanese elm. Grafting of Japanese elm gave up to 60% stand on Siberian elm rootstock and compared favorably with spring budding for propagation of Japanese elm.

Comparison of plant production of *P. × canescens* 'Tower' from 1, 2, or 3 cm root cuttings pretreated in peat moss at 20°C for 1, 2, or 3 wk showed that 2 cm cuttings pretreated for 2 wk was the most productive combination. Auxin pretreatment with 1000 ppm IBA to the root end of the cutting did not increase plant stand.

*Nursery management.* Thirty herbicide treatments were screened against 12 ornamental crop species. Bifenox, alachlor, chloramben, oxadiazon, linuron, and EPTC were generally not harmful to the crop and showed good potential for use, or expanded use, in nursery production. The efficacy of trifluralin alone and in combination with alachlor or linuron was evaluated with positive results in six nursery crops.

Plants of 11 broad-leaved and coniferous species overwintered in containers under snow, under flax straw, and without snow cover were evaluated for survival. Snow and flax straw plus snow prevented cold injury to

## NEW CROPS

roots. The minimum recorded soil temperatures in the three environments were -6.0, -6.2, and -29.0, respectively.

*Fruit breeding.* Budwood of three new prairie-hardy (Zone 2a) apples was distributed to nursery growers in the prairie region. Westland (Heyer No. 12 × Dr. Bill) is a large (7-8 cm) apple with fair eating quality and good cooking quality. Parkland (Rescue × Melba) and Norland (Rescue × Melba) are good quality apples of medium size (6-7 cm). All three apples originated from crosses made at Morden through the Prairie Fruit Breeding Co-operative and were selected at Brooks and Lacombe, Alta., and Scott, Sask., respectively.

### Potatoes

*Breeding and evaluation.* From prairie, regional, and north central trials, 22 advanced cultivars were increased for 1980 and seven cultivars were included in 1979 industry trials. The present most promising cultivars are A68678-1 (late mid-season/French fryer), Oneida (long storage, chipping), Atlantic (chipping), and G712-1 (early chipping).

Cooperative trials with Fredericton have shown enhanced yielding ability of tetraploid × diploid first division restitution (FDR) hybrids. The value of this technique for increasing potato yields was reduced by rough and deep-eyed characteristics of presently available FDR parents.

*Quality.* Sucrose rating (SR) of Norchip and Kennebec investigated at five locations from Nova Scotia to Alberta, with coordination at Morden, appears promising for estimating maturity at harvest and proved to be a good indicator of the breaking of tuber dormancy and loss of chipping quality in storage.

*Herbicides.* Of 14 herbicides evaluated for control of broad-leaved weeds in potatoes, only trifluralin or dinitramine soil-incorporated, followed by metribuzin postemergence, outyielded the weedy checks. Norland, Norchip, Netted Gem, ND8888-2, M69S06-69, A68678-1, G712-1, Nipigon, and Purple 2126 were tolerant of metribuzin. Atlantic, Batoche, Oneida, and ND8891-3 were injured at 1.0 kg/ha applied postemergence while Alaska Red and Wisconsin 729R were susceptible to metribuzin.

### Jerusalem artichoke, chicory

*Evaluation.* Evaluations of Jerusalem artichoke were continued with yields of 23.0 t/ha recorded. Chicory yields ranged from 35.9 t/ha to 49.1 t/ha.

*Management.* Chicory yields were increased with early planting and irrigation but reduced by hilling. Fall seeding resulted in bolting of the crop and production of inferior quality roots.

*Quality.* Cooperative research with the University of Manitoba resulted in progress toward development of a means to extract inulin from plant tubers.

### Pulse crops

*Evaluation.* In soybeans, narrow rows (20 cm) and high plant populations (80-100 plants per square metre) increased yield, particularly of the indeterminate Portage and McCal cultivars. Forty-one new accessions of chickpea were evaluated; 14 of these survived anthracnose disease and matured under Morden conditions.

*Weed control.* Acceptable weed control and high yields of lentils and dry beans were obtained when a dinitroaniline type herbicide was either tank-mixed with chloramben and soil-incorporated, or followed by metribuzin as a postemergence treatment. Dry beans were also tolerant of bentazon.

### Alternative grain crops

*Evaluation and management.* A number of experimental lines of proso millet were identified as having good agronomic characteristics; a large, brown-seeded line (NC22-3), which ranked well in previous cooperative tests, yielded 4872 kg/ha and matured in 78 days. Forage yields of foxtail millets were as high as 6.7 t/ha (dry matter) and seed yields of 4555 kg/ha were recorded for the NC21-20 line. Sorghum, poppy, niger, plantago, and pearl millet lines proved marginal for crop establishment and earliness. Proso millet showed tolerance for several commercial herbicides including MCPA, MCPK, 2,4-D, bromoxynil, dicamba, cyanazine, bentazon, and metribuzin.

## Essential oil and spice crops

*Evaluation.* Variability in coriander, caraway, fennel, dill, and several minor crops was assessed; promising high oil lines were confirmed in coriander.

*Management and quality.* Planting coriander before 100 CHU accumulation and at 4–6 cm depth improved germination and yields.

Caraway yields were improved when planted with a press drill as compared to a disc-type seeder. A plantation of 2.5 ha of monarda was established with support from Agro-Man funding. Herbicides that exhibited sufficient selectivity in coriander and dill to warrant further evaluation were trifluralin, triallate, EPTC, napropamide, chloramben, diclofop methyl, barban, and linuron.

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# Research Station

## Winnipeg, Manitoba

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J. J. NIELSEN, Dr. sc. agr.	Smuts
D. J. SAMBORSKI, B.S.A., M.Sc., Ph.D.	Wheat leaf rust
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L. B. SMITH, B.Sc., M.Sc., Ph.D.	Population dynamics
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R. J. LAMB, B.Sc., M.Sc., Ph.D.	Systems biology
H. G. WYLIE, B.A., Ph.D.	Host-parasite relations

### Departures

K. W. BUCHANNON, B.S.A., M.Sc., Ph.D. Deceased 29 July 1979	Head, Cereal Breeding Section
A. W. CHIKO, B.Sc., M.Sc., Ph.D. Resigned 30 November 1979	Viruses
B. MARCHYLO, B.Sc., M.Sc., Ph.D. Resigned 29 December 1978	Cereal chemistry
W. C. McDONALD, B.S.A., M.Sc., Ph.D. Retired 28 December 1979	Director

## VISITING SCIENTISTS

### *Visiting fellowship*

J. SINGLETON-SMITH, B.A., M.S., Ph.D.                      Sensory physiology

### *Research Associate*

H. A. H. WALLACE, B.Sc., M.Sc.                              Microflora of stored seed

### *Graduate students*

C. AITCHISON, B.Sc., M.Sc.	Entomology
A. AL-HITTY, B.Sc.	Entomology
B. S. JOIA, B.Sc., M.Sc.	Entomology
G. MUSA, B.S.A.	Plant pathology
P. SUDERMANN, B.S.A.	Plant breeding
L. WONG, B.S.A.	Plant breeding

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<sup>1</sup>Seconded from Libraries Division, Finance and Administration Branch.

<sup>2</sup>On transfer of work to the Institute of Animal Resource Ecology, University of British Columbia, Vancouver, B.C., August 1979 to July 1980.

## INTRODUCTION

Work at the Winnipeg Research Station concerns three broad areas of responsibility: development of improved varieties of cereals adapted to regions of the Canadian prairies, research on the protection of stored seed and other agricultural products, and research on the integrated control of insect pests of field crops.

Improvement of cereal varieties, historically the first mandate of the Research Station, involves close cooperation between plant breeders, geneticists, plant pathologists, and researchers concerned with quality screening of lines under development. The latest variety produced as a result of their combined efforts, the common wheat Benito, was licensed in 1979. It is the first of a new generation of bread wheats, containing more than one gene for leaf rust resistance in addition to resistance to stem rust and smuts, and incorporating excellent agronomic characteristics, particularly early maturity.

Research on the preservation of grain and oilseeds and their products is national in scope and involves cooperation with the Plant Protection Division and the Canadian Grain Commission. Control of pests by radiation was conducted in cooperation with the Institute of Physics, University of Mexico.

Research on the control of field crop insects, particularly those that attack rapeseed, through the use of newer chemicals and the development of a management system of integrated pest control is the third area of responsibility at this Station.

This year we were saddened by the death of two members of our research staff. We would like to pay tribute to Dr. Thorvaldur Johnson, a former Director of the Research Station and one of the original staff when the Station was founded in 1925. Dr. Johnson contributed much to the cooperative spirit that developed at the Station between researchers of differing disciplines. As rust pathologist he acquired international fame, and he will always be remembered by his colleagues for his kindness and humanitarianism. Dr. Johnson passed away on 15 September 1979, 17 yr after his retirement. The untimely death, 29 July 1979, of Dr. Ken W. Buchannon, Head of the Cereal Breeding Section, came as a heavy loss to the research community. He had just been appointed as Director of the Morden Research Station. During his 26 yr research career he had received wide recognition for his development of barley lines resistant to cereal diseases.

Further information summarized in this report can be obtained from: Research Station, Research Branch, Agriculture Canada, 195 Dafoe Road, Winnipeg, Man. R3T 2M9.

R. Rohringer  
Acting Director

## BREEDING, GENETICS, AND CYTOGENETICS

### Common wheat

The line B.W. 20 was licensed as the cultivar Benito. Its major attributes are a combination of good yield with earlier maturity. The 3rd yr of Cooperative testing of the line B.W. 37 was completed. This line, a Neepawa\*6/R.L. 4137 backcross, continues to appear promising from the standpoint of sprouting resistance and low  $\alpha$ -amylase activity.

Research on sprouting resistance showed that the testing period for this characteristic

can be extended beyond the immediate harvest period by storage of the seeds at sub-zero temperature or use of high temperatures (30°C) for germination. These tests, in addition to the development of a rain simulator, enabled the expansion of testing for sprouting resistance.

Genetic analysis of the cultivar Terenzio indicated that its leaf rust resistance is controlled by two interacting genes: a 'major' and a 'minor' gene. In the greenhouse both genes are required for seedling and adult plant resistance; however, in the field the 'major' gene appears to give full resistance.

Utilization of wheat relatives as sources of rust resistance included: development of two leaf rust resistant hexaploids using two strains

of *Aegilops squarrosa* L.; and transfer of stem rust resistance from *Triticum longissimum* (Scheinf. & Muschli in Muschli) Bowden and *T. monococcum* L. to hexaploid cultivars.

In tests for resistance to 20 races or cultures of stem rust, it was shown that Canthatch nullisomic 7D and Tetra Canthatch were more resistant than normal Canthatch and ditelosomic 7DL. It was concluded that chromosome 7DL of Canthatch carries a gene, or genes, that suppresses resistance conferred by other chromosomes of the complement.

### Durum wheat

Coulter continued to increase in the area occupied, particularly in Manitoba, where it was the second-place durum wheat cultivar at 31.5% of the area. The most advanced line, D.T. 427, in 3 yr of testing yielded 106% and 112% of Coulter and Wascana, respectively, in the Black soil zone.

A cooperative project on assessment of durum wheat quality testing, involving 30 cultivars of diverse gluten strength, was continued for a 2nd yr. Assessment of the sodium dodecyl sulfate (SDS) sedimentation test showed that it is highly correlated with other measures of gluten strength, such as the mixogram. This test appears to be a promising quality screening tool. Further analysis of the 30 cultivars by polyacrylamide gel electrophoresis confirmed reports of other workers that gluten strength is associated with banding of endosperm proteins. Two bands with designated relative mobilities of 42 and 45 appear to be involved.

### Barley

The two-rowed barley line, T.R. 206, performed well in the 3rd yr of the Cooperative test. This line combines good malting quality with strong straw, high test weight, resistance to stem rust and net blotch, and good yield.

A study was conducted on harvesting (hand versus Hege combine) and drying (natural versus heated air) methods for experimental plots. Quality analysis indicated that harvesting methods affected protein content and amylase activity; drying methods affected protein content and viscosity.

Modifications were made to the test for hordein and the automated enzyme assays,

which improved the quality screening programs. An automated method for determining soluble carbohydrates was also developed.

### Oats

The line O.T. 210 continued to perform well in the 2nd yr of the Western Cooperative oat test. In contrast to the check cultivars, it has good resistance to prevailing races of stem and crown rust, and smut. Its yield has been equal to Hudson, with height and straw strength similar to Random.

Further advances were made in combining good agronomic characteristics and disease resistance. A number of good yielding lines in the rust area test have excellent kernel type, good rust and smut resistance, and apparent tolerance to barley yellow dwarf virus.

## CEREAL RUSTS

### Rust surveys

*Stem rust of wheat.* The 1978 physiologic race survey showed that the wheat stem rust population continues to be widely variable, as it has been since 1974. Nineteen races, including four new ones, were identified using single gene differential hosts. The main races (C53, C33, and C25) were unchanged from 1977. Although race C25 has moderate virulence on seedlings of some widely grown varieties, there was no evidence that any race seriously threatened resistant commercial varieties or advanced plant breeders material.

Results for 1979 show that, as in 1978, nearly all the rust on foxtail barley was rye stem rust. This ubiquitous, susceptible grass was the main source of samples of wheat stem rust for the race survey prior to 1978. In 1978 and 1979, samples for the survey were obtained from plots of the susceptible cultivar Klein Titan specially planted at various locations across Western Canada. Fifty or more samples were obtained from each of five plots of Klein Titan in 1978. However, intensive sampling from a few plots cannot be regarded as adequate for a thorough race survey. In 1979 the number of plots was doubled but unfavorable weather prevented rust development in several of them, especially the most westerly ones. The only available solution to the sampling problem posed by highly resistant commercial varieties and a sharp change in the rust population on foxtail barley is to collect intensively from an increased number of plantings of susceptible

cultivars across Western Canada. Hopefully any new races capable of threatening commercial cultivars will not go undetected.

*Leaf rust of wheat.* Races of wheat leaf rust were identified in 1978 using 19 backcross lines with single genes for resistance as differential varieties. Lines with resistance genes *Lr11*, *Lr16*, *Lr19*, *Lr21*, and T<sup>4</sup> × P.I. 58548 were resistant to all isolates. Twenty-eight virulence combinations on the remaining 14 genes for resistance were identified. There were no changes in the leaf rust population that affected advanced breeders' lines or resistance sources used in current breeding programs at Winnipeg.

Leaf rust was widespread in Ontario in 1978 and greenhouse tests were carried out during the winter on Frederick and Talbot, the most important winter wheat cultivars grown in Ontario. Frederick appears to have only one gene, *Lr1*, for seedling resistance and no additional resistance at the adult plant stage. Talbot has an unidentified seedling gene, or genes, that condition resistance to most, but not all, isolates of leaf rust from Ontario and has additional resistance at the adult plant stage.

*Oat stem rust.* Oat stem rust developed throughout Manitoba and eastern Saskatchewan by late August but crop losses were limited to the western part of the Red River Valley in Manitoba where severe infections at the early dough stage caused heavy losses in late-seeded fields. Several rare races of oat stem rust have been identified but none of these threaten lines going forward for advanced testing.

*Oat crown rust.* The physiologic race survey for 1978 revealed no important changes in crown rust races. In 1979 crown rust developed sporadically. Moderate to severe damage occurred only in a few fields in the western Red River Valley of Manitoba.

In a detailed study of the fine structure of the haustorial mother cell haustorium in *Puccinia coronata* Cda., extensive histochemical tests were utilized. They revealed the sequential development of various parts of the haustorial apparatus.

## Resistance to the rusts

Wheat leaf rust resistance genes *LrT*, *LrEG*, *Lr13*, *Lr14*, and *Lr22* have been incorporated into Napayo and Benito backgrounds, and transfer of other genes to these cultivars was continued in the past year.

Three hundred new oat accessions from Turkey and Iran were evaluated for stem rust and crown rust resistance. One hexaploid line with intermediate resistance to stem rust and a good range of resistance to crown rust were found. About 1000 accessions in the genetic resource development program were increased for storage in the Ottawa gene bank.

Inheritance studies with oats demonstrated the genetic basis of resistance to stem rust conferred by genes Pg-15 and the Pg-a complex. Genetic studies on crown rust resistance in *Avena sterilis* L. revealed two 'major' genes and a third 'minor' gene in accession CAV 3548. Genetic studies on accessions CAV 1358 and CAV 1376 demonstrated that at least three complimentary 'minor' genes are responsible for their resistance.

## Molecular biology of the cereal rusts

Lectins conjugated to ferritin as electron-dense markers were found to be unsuitable as histochemical reagents because they bound nonspecifically to the plastic embedding material in ultrathin sections. Lectins have been conjugated with gold particles to avoid nonspecific binding. Rust colonies were isolated from infected wheat leaves in high yield with a minimum of contaminating host material, but their viability was low and they did not contain haustoria. It is not known if the hyphal walls have been modified during enzymatic maceration of the infected leaves. Purified germ tube walls were found to contain little fucose. This methylpentose is present in large amounts in nonpurified germ tubes and is characteristic for most cell surfaces. Evidently, fucose-containing macromolecules have been lost during cell wall purification, necessitating the use of more gentle extraction techniques. Extracts from near-isogenic lines of wheat leaves have been fractionated into 75 proteins using a two-dimensional gel electrophoresis/isoelectric focusing system. Two additional proteins were detected in the *Sr6* line near the limit of detection, requiring a more sensitive visualization technique.

## OTHER CEREAL DISEASES

## Viruses

### Smuts

Smut was found in 78% and 73% of the barley fields examined in 1978 and 1979, respectively. Analysis of collections obtained from barley in 1978 revealed no change in the biotypes present, although two collections from Ontario were virulent on the widely used Jet type of resistance to loose smut. A collection of loose smut on wheat obtained in 1978 in Western Canada yielded a race of *Ustilago tritici* (Pers.) Rostr. that is virulent on the durum wheat cultivar Wakooma.

In searching for new races that could assist in breeding programs, 13 collections of loose smut of wheat from Turkey, Iran, Yugoslavia, Pakistan, and Brazil were tested. Race T26, with virulence on Wakooma, and race T27, which is virulent on the general susceptible but avirulent on the other 18 differential cultivars, were identified in the Turkish collections.

Infection studies with the cereal and related smuts revealed the following new hosts: *Hordeum pusillum* Nutt. (native to North America) and *H. hexaploidum* Covas (native to South America) are susceptible to both *U. tritici* and *U. nuda* (Jens.) Rostr.; *H. roshevitzii* Bowden is susceptible to *U. tritici*; *Agropyron fibrosum* (Schrenk) Nevski and *Elymus canadensis* L. are susceptible to *U. turcomanica* Tranzsch.; *A. caninum* (L.) P. Beauv., *A. fibrosum*, *E. dahuricus* Turcz., and *H. jubatum* L. are new hosts for *U. aegilopsidis* Picbauer.

### Foliage diseases

A search for resistance in barley to *Pyrenophora graminea* (Ito & Kurib.), the cause of leaf stripe, by testing 38 cultivars with four isolates of the pathogen, revealed that the cultivar Betzes is immune and Fairfield and Palliser are resistant. The remainder of the cultivars in the test are susceptible. Six-row barleys tended to be more susceptible than two-row cultivars.

Field inoculation of the barley cultivars Klages and T.R. 206 with *P. teres* (Died.) Drechsl., the fungus causing net blotch, was carried out successfully. Multiple inoculation resulted in the greatest disease development. Symptoms were significantly less severe on T.R. 206, which is a resistant selection, than on Klages.

About 1800 lines and cultivars of oats were inoculated in field plots with a virulent strain (aphid nonspecific) of barley yellow dwarf virus (BYDV). At least two new lines were found to have a useful degree of tolerance and the tolerance found earlier in some other lines was confirmed.

A greenhouse trial in which several lines and cultivars of two-rowed barley were inoculated with BYDV revealed that T.R. 206, a line developed at Brandon, was tolerant. This line is now being used in the Winnipeg program. Advanced lines of six-rowed barley from Brandon with the *Yd<sub>2</sub>* gene were tested in a growth cabinet with BYDV. Some of the lines showed a high degree of tolerance to the virus.

The median latent periods of three strains of BYDV in the aphid vector were determined. The latent period per aphid was defined as the time lapse from the start of the acquisition feeding period to the middle of the inoculation day during which transmission of an infectious dose of virus first occurred. At 15°C and 20°C, the median latent periods for *Sitobion avenae* (Fab.) with *S. avenae*-specific isolate 6407 were 65.5 and 44.5 h, respectively; for *Rhopalosiphum padi* (L.) with *R. padi*-specific isolate 6524 the values were 50.1 and 35.0 h. A decrease equivalent to 50% in the median latent periods for a 10°C increase in temperature was found with the two aphid-specific isolates but the decrease was more than 50% with the aphid-nonspecific isolate.

Inefficient transmission of isolate C4 of barley stripe mosaic virus (BSMV) from barley to wild oats, followed by highly efficient transmission of the isolate from infected to healthy wild oats, was previously noted and this pattern of transmission was attributed to strain selection. In another series of transmission tests, the efficiency with which isolate C4 was transmitted from barley to wild oats increased with the number of times (one to three) the isolate had been previously passed through wild oats. After three previous consecutive passages through wild oats, the isolate was transmitted from barley to nearly all wild oat plants inoculated. These results suggest that complete separation of strains comprising isolate C4 did not occur until after three consecutive passages of the isolate through wild oats.

## STORED PRODUCTS PROTECTION

### Biology

In laboratory tests on the keeping quality of a hull-less variety of oats, cv. Terra, viability was lost more rapidly than in the hulled variety Random at 20°C and 90–100% relative humidity (RH). This was probably because of the greater *Penicillium* infection that occurred in the Terra oats. Fat acidity values of Terra oats increased rapidly with KOH from 35 mg/100 g of seed to 87–118 mg/100 g of seed, when seeds were stored at 90–100% RH. Terra oats provided a more favorable substrate for the multiplication of the mites *Tyrophagus putrescentiae* (Schrank), *Acarus farris* (Oudemans), and *Lepidoglyphus destructor* (Schrank) than did Random oats. Each of two 11.5 t lots of mature Terra oats of 9.7–10.5% moisture content stored in wooden farm bins in Manitoba, during 1976–1978, were stored safely with very low levels of infestation by preharvest fungi and insects, and negligible quality loss for up to about 20 mo. Later, when grain moisture content in the bottom layers of grain in each of the bins rose from 10 to 13–16%, heavy floor level infestations by the fungi *Penicillium* and *Aspergillus versicolor* (Vuill.) Tiraboschi, and mites *Caloglyphus berlesei* (Michael) and *Tarsonemus granarius* (Lindquist) occurred. With time, fat acidity values rose from 1st yr KOH levels of about 30 to 50–78 mg/100 g of dry grain. Populations of *Cryptolestes ferrugineus* (Stephens) and *Tribolium castaneum* (Herbst) introduced to one bin did poorly during the first summer and failed to survive during the 2nd yr. A third species of beetle, *Oryzaephilus surinamensis* (Linnaeus), continued to multiply in small numbers after 22 mo.

Guidelines for safe storage of rapeseed based on mycological and biochemical assessment and expressed in terms of seed moisture and temperature at binning were prepared. With these guidelines it was possible to predict whether or not seed should be dried before storage. Studies on the deterioration of dried and moist freshly harvested rapeseed in small-scale drum experiments showed that deterioration of moist seed began within 24 h of harvest but was slowed by drying. After 67 wk storage, moist seed, unlike dried seed, had reduced viability and high levels of postharvest spoilage molds. Mycological and other changes occurring in stored crops in the Red

River Valley after the 1979 flood were investigated in laboratory flood-simulation experiments. Aflatoxin B<sub>1</sub> at 425 ppb was present in flax from a flooded bin at Morris. Mold development occurred in the bin as a result of upward movement of water and also from wave action. From these studies guidelines were derived for optimal salvage, by producers, of grain from flood-damaged bins.

Ochratoxin A, a potent mycotoxin affecting the liver and kidneys, was formed in barley and wheat but not in oats stored in a farm granary in Manitoba during the summer and fall of 1979. Detectable amounts found in wheat and barley after 4 wk increased after 20 wk to 640 ppb in wheat and 3850 ppb in barley. To explore the suitability of fungal odors as an early warning sign of mycotoxin formation, intergranular air from the crops was analyzed by gas chromatography. The well-known fungal odors 3-methyl-1-butanol, 3-octanone, and 1-octanol increased 10- to 15-fold by 7 wk, and declined to control levels by 16 wk.

A flour beetle assay, developed at the Research Station, was used to evaluate protein quality in barley. Larval development time of *Tribolium confusum* Jacqueline du Val was significantly shorter on three high-lysine barley lines than on two lines and two cultivars with low-lysine content. The bioassay was used to determine the effect of interaction between three diets and five temperatures from 25 to 35°C. The effect was most pronounced on the poorest diet (a hull-less barley line) at the lowest and highest temperatures.

Studies of the life history of the larger grain borer, *Prostephanus truncatus* (Horn), a major pest of stored corn in Mexico, have shown that because of its susceptibility to low temperatures it is unlikely to become a pest of unheated storages in the Prairie Provinces. It has been reported from British Columbia. It can complete its development in 30 days at 30°C and 70% RH on crushed wheat or crushed corn. The lower limit of development is 18°C. It has the ability to become established in regions of British Columbia and Eastern Canada that are not subject to prolonged periods below the development threshold temperature.



## Control

The effect of rapidly lowering the temperature of stored grain was studied on the rusty grain beetle and the foreign grain beetle, a fungus-feeding beetle similar in size to the rusty grain beetle and often mistaken for it by farmers and elevator managers. When adults of each species were exposed to a temperature decrease from 15°C to -5°C within 1 h and maintained at the lower temperature for 1 wk, the mortality of the rusty grain beetle was 38% in contrast to 100% mortality of the foreign grain beetle. To achieve complete mortality of rusty grain beetles, a temperature decrease from 15°C to -15°C was required. These results indicate that cooling grain quickly below freezing would eliminate foreign grain beetles but not rusty grain beetles, unless a temperature of about -15°C was obtained.

In cooperation with the University of Mexico, experiments with a pilot plant electron accelerator showed that radiation effectiveness for the control of *T. castaneum* in stored corn was a function of the applied dose (7–25 krad) but not of radiation intensity, expressed as dose rate (1.9–30 krad/min). Radiation was more effective than fumigants against immature stages of *T. castaneum*.

Techniques were developed for testing the effectiveness of carbon disulfide (CS<sub>2</sub>) for the control of the mite *L. destructor* in wheat. CS<sub>2</sub> at a rate of 10 mL/100 kg wheat killed eggs and mobile mites satisfactorily, but mites in the immobile hypopal stage survived. Reinfestation of wheat by the mite after treatment with CS<sub>2</sub> is probably due to the tolerance of the hypopi for the fumigant.

Pine wood sawdust impregnated with malathion at 20.5 mg of active insecticide per gram of sawdust provided complete control of *T. castaneum* adults on treated concrete surfaces for 12 wk. By contrast, malathion sprayed on concrete at 1 g/m<sup>2</sup> was effective for up to 3 days after treatment. Treated sawdust applied to wood or metal surfaces persisted for 16 wk against *T. castaneum* adults.

A trap incorporating silica gel and an attractive food (oatmeal or sunflower seeds) on an adhesive-coated base was developed and used successfully in laboratory tests to control merchant grain beetles. Oviposition by red flour beetles was almost totally suppressed after a 1 wk exposure to wheat treated with BAY SRA-1660 at 10 ppm in hexane or

absolute alcohol. Survival was 98% in wheat treated with either solvent, but progeny production was lower and progeny mortality higher in hexane-treated than in alcohol-treated wheat.

## FIELD CROP INSECTS

### Grasshopper surveys

The forecast of grasshopper infestations in Manitoba for 1980 showed that the area infested had more than doubled, and the density of populations was expected to be twice that of 1979. Of the area expected to be infested by grasshoppers in 1980, 2207 km<sup>2</sup> were rated light, 1284 km<sup>2</sup> moderate, and 311 km<sup>2</sup> severe, for a total of 3802 km<sup>2</sup>. The largest area was in the south-central part of the province and extended from Neepawa and Gladstone south to the Assiniboine River. Infestations were largely light to moderate with a severe infestation located between Arizona and Lavenham. The second largest area was east of the Red River and covered the southern third of De Salaberry Municipality and most of the Municipality of Franklin. Infestations were light throughout, except for a small area between Green Ridge and Tolstoi which was severely infested.

### Sugar beet insects

Counter, Lorsban, Temik, and Dacamox, as in-furrow granular treatments, were effective against the sugarbeet root maggot and against wireworms and cutworms. Yields of beets treated with these materials were 15–18% greater than those of beets treated with Furadan.

A number of insecticides were effective against the Colorado potato beetle when applied as foliar sprays. Treated potatoes yielded 110–450% more than untreated potatoes.

## INTEGRATED CONTROL OF INSECT PESTS

### Flea beetles

Flea beetles were again the major insect pest of rape in Manitoba in 1979. Most growers used either an in-furrow application of granular insecticide or seed treatments to minimize damage to newly germinated seedlings. Several of the insecticides tested as seed

dressings for the control of flea beetles on rape provided seedling protection during emergence, but most were ineffective thereafter. Oftanol, which was outstanding in 1978, provided some protection in the postemergence period in tests in 1979; this was reflected in a significant yield increase (9%) over that of untreated rape. Lindane-based seed dressings were ineffective in terms of yield response. In-furrow granular treatments were moderately to highly effective and were generally associated with reduced plant damage and enhanced plant development and yield; plots treated with Facam, a new entry in 1979, yielded about 15% more than untreated plots. There was no difference in effectiveness of a lindane seed dressing when applied, for control of flea beetles, with a discer-seeder or a seed drill, but an in-furrow treatment with Furadan granules was less effective with the discer than with the drill; seed and granules are more widely dispersed with a discer than with a drill.

Flooding from the Red River in spring hampered establishment studies of the European braconid parasite *Microctonus bicolor* Wesmael. This parasite had been released in 1978 in an attempt to reduce the abundance of *Phyllotreta cruciferae* (Goeze) and *Phyllotreta striolata* (F.), the two most important flea beetle pests of rapeseed in Manitoba. Additional releases of *M. bicolor* were made during July, August, and September 1979. Laboratory tests indicated that *M. bicolor* preferred or survived better on *P. striolata* than on *P. cruciferae*. Studies of color variability in the native parasite *Microctonus vittatae* Mues were completed. Additional details of the biology, life history, and host preferences of *M. vittatae* were obtained.

Trap strips of winter rape (*Brassica napus* (L.) and *B. campestris* (L.)) were sown by growers around two fields in the Dugald area. A third field was used as a control. Preliminary analyses indicate that the flea beetle density was much higher in the trap strips than in the main crop in both spring and fall. Insecticidal spraying was effective in killing large numbers of beetles but late planting, uneven germination, and the generally low numbers of flea beetles make the results less conclusive than was hoped. Work on an index of rape seedling damage was delayed because the planned sowing area and adjacent pest overwintering areas were flooded. The effects of trap height and weather on sticky-trap catches of flea beetles were assessed. The

method continues to show promise as a management tool farmers might use prior to seeding, to anticipate invasions of rape fields by the pest.

The population densities of flea beetle life stages were assessed in two varieties of rape and one variety of mustard. Observations that spring adults show feeding preferences among varieties were confirmed and quantified, with the order of preference being Candle, Tower, and Gisilba. These preferences were also reflected in oviposition rates and densities of the next generation of beetles. Laboratory and field studies showed that pod hairiness conferred protection to mustard pods whereas adjacent smooth rape pods were heavily damaged.

During the diapause phase of *Phyllotreta cruciferae* two different refractory periods were discovered: a thermorefractory period beginning from the onset of diapause and lasting 3–5 wk during which time the insects are insensitive to higher temperatures (e.g. 25°C); and a photorefractory period, lasting till past winter solstice, when the beetles enter the phase of quiescence. The beetles are cold hardy during this period and during quiescence. The acquisition of diapause characters, especially the thermorefractory quality, is an adaptation by these insects to overcome any short periods of high temperatures during late summer and autumn. *Phyllotreta striolata* has a reproductive diapause (gonotrophic dissociation). As in *P. cruciferae*, five different physiological phases can be differentiated as prediapause, diapause, quiescence, maturation, and oviposition phases in the adult life. The morphological, physiological, and behavioral characteristics of these phases are similar to those of *P. cruciferae*. Further, the field populations were distinguished into four categories as early-spring, late-spring, fall, and winter populations. Early-spring populations (late April) laid eggs for a period of 30–40 days and no more eggs were laid after that time (unlike *P. cruciferae*). Late-spring populations (late May) were erratic in their oviposition habit. A definite temperature preference was established. *P. striolata* prefer 20°C to 25°C for ovarian maturation (unlike *P. cruciferae*). A laboratory-reared F<sub>1</sub> generation of 100 flea beetles produced 700 L<sub>1</sub> larvae for which 50 F<sub>2</sub> adults were reared on radish slices. No eggs were obtained from the F<sub>2</sub> generation and the culture was not sustained. Juvenile hormone, applied topically either as an initial or as a weekly treatment, did not

increase oviposition of field collected beetles. The rate at which beetles resumed reproductive cycling after being field collected was positively associated with intensity of illumination. Confining adults over rape seedlings growing on damp filter paper is an improved method for collecting and hatching eggs and maintaining newly hatched larvae.

### **Bertha armyworm**

In Manitoba, populations of *Mamestra configurata* Wlk. increased in 1979. Sex attractant traps at 10 locations caught 88 male moths, 1.5 times more than in 1978, and the number of larvae found in 40 fields at these locations averaged 0.2/m<sup>2</sup>, eight times higher than in 1978. In addition two infestations were found near Dauphin in which larval densities were 4.4/m<sup>2</sup> and 5.4/m<sup>2</sup>. Parasitism in these more heavily infested fields was not as high as in the fields near the sex attractant traps but diseases (mainly a nuclear virus) caused over 50% mortality.

Larvae in instar IV (which are sensitive to photoperiod) were released at three different latitudes (50, 51.5, and 52.5°N) at various times (mid-June, mid-July, and mid-August) to test the effect of latitudinal fluctuations of day length and temperature on diapause induction. All pupae entered diapause at all latitudes studied when larvae were released during mid-August. However, only 27% of pupae entered diapause at 50°N when larvae were released during mid-June. The proportion of diapausing pupae were much higher (e.g. 89–93%) when larvae were released during mid-July and mid-August at all latitudes tested. Preliminary analyses of the effects of cold stress on diapausing pupae indicate that these effects can be modeled with fairly simple equations. Pupae surviving cold stress emerge as adults later than do pupae in groups which have not suffered mortality from exposure to cold. There is evidence that threshold for the initiation of postdiapause development is higher than the threshold for postdiapause development. This could affect the accuracy of our prediction of moth flights in years with low overwintering survival. A screening program begun last year has identified two chemicals that alter the incidence of diapause when the chemicals are fed in the larval diet of *M. configurata*. The chemicals are structurally related to naturally occurring insect brain transmitters. Progress

in screening and testing of promising chemicals continues to be slow because of the large amount of time needed to assay each substance for its effect on diapause. This limitation can be partially overcome by judicious choice of the chemicals to be screened, which in turn depends on a still-imperfect knowledge of basic nervous system processes that govern diapause. Studies of the pupal brain of *M. configurata* during the initiation of postdiapause development have revealed that amines, amine-stimulated adenylate cyclase, and cyclic AMP are probably not initiators of development *per se*. The development of an enhanced octopaminergic system during brain ontogeny is needed, however, to process or modulate the greatly increased sensory input of the adult. Preliminary findings indicate that an amino acid transmitter may participate in the initiation process. Techniques for obtaining highly radioactive [<sup>14</sup>C]-octopamine from [<sup>14</sup>C]-tyramine *in vitro* and *in vivo* have been developed and will be used in experiments to establish the natural isomer of octopamine in insects.

The frequency of the black color phase in mature bertha armyworm larvae is dependent on green food and high light intensity. If larval density is also a factor it operates at a level that is too low to be used for indicating economically damaging populations. A series of multiple linear regression equations were developed to relate temperature in a rape field to meteorological records taken under standard conditions. Winter soil temperatures from Beaverlodge, Alta., were analyzed and summaries prepared. Soil and canopy temperatures were recorded in a rape field through the spring and summer.

### **Red turnip beetle**

Populations of *Entomoscelis americana* Brown again remained at low levels in Manitoba. Local infestations were found near The Pas. No insect parasites were found in larvae collected from these fields. The studies to determine the effects of burying eggs in soil on egg survival were completed successfully in 1979. The data showed that fall cultivation will significantly reduce the survival of red turnip beetle eggs. A study on the effect of temperature on egg survival was conducted during 1979 and will be repeated during the winter of 1979–1980. Most red turnip beetle eggs survived exposure to –20°C for 6–8 wk. A study on the effect of temperature on

hatching time was completed successfully during 1979 and the data have been fitted to a phenological model which will be used to predict the hatching of red turnip beetle eggs in the field.

### Strawberry cutworm

The natural host of the strawberry cutworm, *Amphipoea interoceanica* (Smith), was found to be wild strawberry, and a sex attractant trap survey showed the species to be present in all strawberry-growing areas of Manitoba. The density of the pest in cultivated strawberries varied directly with the

number of years each grower had raised strawberries. Continued studies on the insecticidal control of this cutworm showed that 920 g of chlorpyrifos applied in 1400 L water per hectare gave 90% control of the pest (as measured by field larval mortality) and resulted in a threefold increase in plant stand per unit area. Additional trials with male sex attractants gave no significant improvements over those made in 1978 but traps placed 1 m above crop level caught significantly more moths than traps at 30 and 60 cm. Seven species of Hymenoptera, one of Diptera, and one of *Cordyceps* fungus were parasitic on the larvae or pupae of the cutworm. Total parasitism was 22.5%.

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# Research Station

## Melfort, Saskatchewan

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D. J. EWANUS, B.Sc.	Farm Manager

### Forage Production and Utilization

J. A. ROBERTSON, B.Sc., M.Sc., Ph.D.	Program leader; Beef cow management, pasture utilization
S. E. BEACOM, B.Sc., M.Sc., Ph.D.	Utilization of harvested forages
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D. H. MCCARTNEY, B.Sc., M.Sc.	Beef cow management systems
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### Cereal, Oilseed, and Special Crops Production and Utilization

K. E. BOWREN, B.S.A.	Program leader; Crop production
A. G. CASTELL, B.Sc., M.Sc., Ph.D.	Crop utilization – swine nutrition
W. F. NUTTALL, B.S.A., M.Sc., Ph.D.	Soil fertility

### Departure

D. J. WARNOCK, B.Sc., M.Sc. Resigned December 1978	Cereal, oilseed, and special crop evaluation
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## INTRODUCTION

The Melfort Station serves one of the most potentially productive agricultural areas in Canada. Because of the diversity of agricultural production, our research is aimed at solving practical problems in forage crops evaluation, production, harvesting, storage, and utilization, and in cereal, oilseed, and special crops evaluation, production, and utilization. A diversified livestock program involving beef cows, feeder steers and heifers, ewes and lambs, and feeder pigs is carried out to evaluate crops, crop by-products, crop residues, pastures, and forage harvesting systems.

Brief summaries of some of our work are presented here. For more details readers may refer to the publications listed at the end of this report or may obtain a copy of our *Research Highlights* by writing to Research Station, Research Branch, Agriculture Canada, P.O. Box 1240, Melfort, Sask. S0E 1A0, or by phoning (306) 752-2776.

S. E. Beacom  
Director

### FORAGE PRODUCTION AND UTILIZATION

#### Response of bromegrass and alfalfa pasture to S fertilizer

Application of N at 45, 90, and 180 kg/ha; P at 20 and 78 kg/ha; and S at 22 and 45 kg/ha to bromegrass (*Bromus inermis* L.) and alfalfa (*Medicago media* Pers.) pasture on a Gray Luvisol soil increased herbage yield from 1955 kg/ha (control) to a maximum of 4783 kg/ha with N at 180 kg/ha and P at 78 kg/ha. However, yields were increased from 3898 kg/ha, with N at 90 kg/ha and P at 20 kg/ha, to 4692 kg/ha by applying additional S at 45 kg/ha. Sulfate-sulfur in the control plots measured 5.6  $\mu\text{g}/4$  g soil to a depth of 60 cm.

#### Effect of Avoparcin on animal gain on pasture

Addition of Avoparcin (Cyanamid), a growth-promoting antibiotic, to a mineral mix for yearling beef heifers on pasture increased average daily gain from 0.44 to 0.63 kg. Gain per hectare was increased by 20.4 kg.

#### Cow-calf management systems

Weights at weaning were ca. 50 kg higher for early-born (January–March) than for late-born (March–May) calves. Winter feed costs were increased by \$9 per cow for the early calving treatment versus the late.

Utilizing Russian wild ryegrass (*Elymus junceus* Fisch.) for spring and fall grazing extended the season by 22–35 days (15–29%) in 1978 and by 12 days (9%) in 1979.

Application of N at 45 kg/ha and  $\text{P}_2\text{O}_5$  at 22.5 kg/ha of pasture allowed a reduction in pasture area required per cow-calf unit from 1.46 ha (nonfertilized control) to 1.11 ha. Concurrently, cow-calf gain per hectare increased by 54 and 30% for the early and late calving groups, respectively, compared to the cattle grazing the nonfertilized control pasture.

#### Evaluation of forage cultivars

*Grasses.* Chief has been the most productive cultivar of intermediate wheatgrass, *Agropyron intermedium* (Host) Beauv., at Melfort. Recently, it was outyielded by the selection SCI 3733 which has been recommended for licensing as the variety Clarke. The smooth bromegrass (*Bromus inermis* Leyss.) cultivar Magna has produced 10% more forage but 25% less seed than the next best cultivar, Carlton. The crested wheatgrass [*Agropyron cristatum* (L.) Gaertn.] cultivar Parkway has continued to yield more forage than Fairway. The Russian wild ryegrass (*Elymus junceus* Fisch.) cultivar Swift yielded slightly more forage and substantially more seed than the cultivars Sawki, Cabree, and Mayak.

*Legumes.* Beaver produced at least 9% more forage than other alfalfa cultivars, even though it is somewhat less winter-hardy than Rambler. With proper management, less winter-hardy cultivars such as Angus, Algonquin, and Titan have averaged 250 kg of seed per hectare annually over a 5 yr period.

## Effects of four applications of herbicides to established alfalfa for hay

Applications of 2,4-D [(2,4-dichlorophenoxy)acetic acid] at 0.5 kg/ha in late fall or early spring in each of the years 1975–1978 to established alfalfa resulted in a decrease or no increase in hay yields, depending on the year. Simazine [2-chloro-4,6-bis(ethylamino)-s-triazine] at 1.0 kg/ha also did not improve alfalfa yields. Use of dichlobenil (2,6-dichlorobenzonitrile) at 2.0 and 4.0 kg/ha; Terbacil (3-*tert*-butyl-*s*-chloro-6-methyluracil) at 1.0 and 2.0 kg/ha; or Velpar [3-cyclohexyl-6-(dimethylamino)-1-methyl-*s*-triazine-2,4-(1*H*, 3*H*)-dione] at 0.5 or 1.0 kg/ha either increased or did not affect forage yields. In general, alfalfa yields were not affected significantly during the first 2 yr, but were affected in the next 2 yr. Increased yields were paralleled by decreases in broad-leaved weeds, mainly narrow-leaved hawk's-beard and dandelion, and a decrease in yields in 1978 was due to alfalfa damage caused by 2,4-D.

## Studies on the brome grass seed midge

Excellent control of both generations of the brome grass seed midge, *Contarinia bromicola* (Marikovskij & Agafonova), under field conditions was obtained with carbofuran at 0.14 kg/ha or dimethoate at 0.56 kg/ha applied at the preflower stage.

## Yield response of Rambler alfalfa herbage to S fertilizer

Fertilizers were applied to Rambler alfalfa, *Medicago media* Pers., at rates of 10, 22, 45, and 67 kg N; 10 and 20 kg P; and 22 and 45 kg S (sulfate-S) per hectare over a period of 5 yr. Yields ranged from 3842 kg/ha for the control to 5813 kg/ha with 45 kg N, 20 kg P, and 45 kg S per hectare. The increased yield due to S was 1089 kg/ha averaged over the period. Control plots (to a depth of 60 cm) contained 9.5  $\mu\text{g}$  S/4 g soil (range of 4.9–18.5).

## Development of Schwarting and Melfort hay drying towers

An electronic mechanism consisting of relays, controlled by a rain-sensitive device and a timer, was developed to control the drying fan in both hay towers. The unit shuts off the fan at the onset of a shower and turns it back on when the sensor dries. If the rain persists the fan is operated intermittently to

prevent overheating of the hay. The distribution of incoming forage in the Melfort hay drying tower has been improved by replacing the spinning disc silage distributor and twin augers with a single-auger, open V trough conveyor. The system permits the automatic raising of the roof as the forage is added thus allowing one operator to handle the filling operation.

## Preservation of high-moisture hay

Addition of 2% (w/w) ammonia completely inhibited molding in baled, high-moisture (35%) alfalfa hay and reduced digestible organic matter losses by 20% compared with high-moisture control and 10% compared with the low-moisture control. One percent of ammonia was only partially effective in inhibiting mold. Similarly 2% ammonia completely inhibited molding in high-moisture (31%) brome grass hay while 1% ammonia was only partially effective. Small-scale tests indicated that 3.6% urea (w/w) will inhibit molding of high-moisture brome grass and alfalfa hay, but toxicity of residual urea may be a problem.

## Supplementing ground hay rations for finishing steers and lambs

Adding 3% acidulated fatty acids (AFA) to a ground (1.27 cm) good-quality alfalfa-brome steer finishing ration had no effect on rate of gain (ADG) (1.41 kg per head per day) and improved feed efficiency (FE) by 4% and dressing percentage (DP) by 1.2 percentage units (% U), to increase returns to labor (RL) by \$16 per head. Supplementing the grain control ration with AFA improved ADG by 5% and FE by 10% to increase RL by \$7 per head. Adding monensin (trade name Rumensin) to the forage control ration reduced ADG by 8%, improved FE by 2.5%, and reduced DP by 0.8% U to reduce RL by \$17 per head. Adding monensin to the forage plus AFA ration reduced ADG by 2%, FE by 4%, and DP by 0.5% U to reduce RL by \$12 per head. Adding 3% of tallow to the forage control ration increased ADG by 6%, FE by 11%, and DP by 0.3% U, but because of the high cost of tallow, reduced RL by \$4 per head. Pelleting the good-quality hay (17% crude protein, 57% digestible organic matter) caused bloat and cannot be recommended.

## PRODUCTION AND UTILIZATION OF CEREALS AND SPECIAL CROPS

### Cultivar evaluation

*Wheat (Triticum aestivum)*. Sinton, a recently licensed spring wheat, outyielded Neepawa, a commonly grown cultivar, by 260 kg/ha over the past 3 yr. However, producer experience and field trials show that it weathers badly in the swath. This, coupled with the fact that Sinton shatters more readily and that its yield was lower than Neepawa at two other test sites, is restricting its acceptance by producers in the area.

*Barley (Hordeum vulgare)*. Elrose, a newly licensed two-row malting barley, yielded 274 kg/ha less than Klages but about 200 kg/ha more than Betzes in 1979 on the average at three test sites in the area. Elrose was 3 days earlier in maturity and is otherwise similar to Klages.

*Rapeseed (Brassica species)*. *B. napus* (cultivars Regent and Altex) and *B. campestris* (cultivar Candle) rapeseed yielded 2831, 2654, and 2195 kg/ha, respectively, at Melfort and 1823, 1613, and 1212 kg/ha, respectively, at Meath Park in 1979.

*Pulse crops*. Tara, a newly licensed cultivar of field peas that has greater resistance to powdery mildew, yielded 6779 kg/ha compared to 5007 kg/ha for Century in 1979. Laird lentils yielded 2639 kg/ha on the average in 1978–1979 and a field of fababeans yielded over 3000 kg/ha at Melfort in 1979.

### Effect of S fertilizer on yield of Bonanza barley and Torch rapeseed grown on stubble

N was applied at 10–67 kg/ha, P at 10 and 20 kg/ha, and S at 22 and 45 kg/ha over a 3 yr period on a Gray Luvisol soil. Application of 45 kg N, 20 kg P, and 22 kg S per hectare maximized the yield of barley (*Hordeum vulgare* L.) (3565 kg/ha). Without S, the yield was 3167 kg/ha and the control without fertilizer was 2709 kg/ha. Similarly, maximum yield (1388 kg/ha) of Torch rape (*Brassica campestris* L.) resulted from the application of 67 kg N, 20 kg P, and 45 kg S per hectare. Without S, the yield was 1194 kg/ha and the control without fertilizer was 798 kg/ha. Control plots (to a depth of 60 cm) contained 8.1  $\mu\text{g}$  S/4 g soil for barley and 10.1  $\mu\text{g}$  S/4 g soil for rape.

### Weed control

BAS 9052 gave good control of wild oats and other grassy-type weeds and volunteer cereals without damaging rape in 1979. Dowco 290 showed promise for controlling thistles and some other hard-to-kill broad-leaved weeds in rape. DPX 4189 showed promise for controlling broad-leaved weeds in wheat and barley and combinations of contact and translocated herbicides were effective for controlling weeds on summerfallow.

A tank mixture of triallate and trifluralin incorporated to a depth of 5 cm gave adequate control of wild oats in rapeseed.

### Chemical summerfallow

Chemical summerfallow produced the highest (3116 and 3537 kg/ha) and straight tillage the lowest (2557 and 3387 kg/ha) yields of seven methods of summerfallowing in 1979 and over a 14 yr period, respectively. Zero tillage seeding gave higher yields (averaging 12.6%) than conventional seeding on the seven fallow treatments in 1979.

### Zero-till seeding

An evaluation of several minimum and zero-till methods of seeding spring wheat on stubble showed that direct seeding with a discer produced the highest yield in 1979. Direct seeding with a narrow shovel hoe-press-drill into standing winter wheat stubble produced the highest yield of winter wheat in 1979.

### Harvesting studies

Swathing at about 25% kernel moisture content (KMC) gave the highest yield of Bonanza barley in 1979. Shattering commenced at 36% KMC and became severe at less than 25% KMC.

### Evaluation of crop residues

Yearling wethers fed fababean, sunflower, field pea, and wheat crop residue consumed about 100%, 85%, 33%, and 33% as much dry matter, respectively, as when fed alfalfa brome hay. Crude protein content was 12.1, 10.8, 6.6, 9.2, and 4.6% and in vivo energy digestibility was 56.1, 50.5, 56.8, 40.9, and 47.9% for the hay, fababean crop residue, sunflower crop residue, field pea crop residue, and wheat straw, respectively. The results indicate that the feeding value of fababean and sunflower crop residue is relatively high.

## Evaluation of barley cultivars

Two-row (Fairfield, Fergus, and Klages) and six-row (Bonanza, Klondike, and Peguis) barleys, grown in 1978, were identically supplemented and fed ad libitum to pigs from 22 to 92 kg. Live performance and carcass measurements were not affected ( $P > 0.05$ ) by cultivar but diets based on two-row barleys tended to be more efficiently utilized, be more palatable, and contain greater proportions of digestible energy and nitrogen compared to six-row barleys.

## Rapeseed in diets for market pigs

Ground Canola seed (*B. campestris* 'Candle') was included as 0-15% of six pelleted diets (15.5% CP), fed twice daily over the period from 22 to 90 kg. Optimum performance and carcass measurements were obtained with pigs fed the 6% rapeseed diet. At higher level of inclusion, performance did not improve but there was evidence of an increasing incidence of visually soft fat in the carcass, a change attributable to increases in the percentages of unsaturated fatty acids, notably 18:2 (linoleic) and 18:3 (linolenic).

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# Research Station

## Regina, Saskatchewan

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Forage and new crops

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## INTRODUCTION

This report outlines the work done in 1979 at the Experimental Farm at Indian Head and the Research Station at Regina.

The Indian Head establishment is operated as a substation. The program evaluates new cultivars of cereal, forage, oilseed, and pulse crops for adaptability to conditions in southeastern Saskatchewan. Management research designed to increase efficiency of production of those crops is also conducted, as well as long-term rotation experiments.

The Regina station is the center for weed control research in Canada. Four programs, biological control, weed physiology, weed ecology, and herbicide behavior in the environment, are under way. In 1979, Miss Betty Guild joined the staff at Regina to serve as information officer and as secretary of the Wild Oat Action Committee. Mr. Dave Mallough went on a leave of absence to serve on a 2 yr CIDA assignment on wheat production in Tanzania.

The facilities at Regina and Indian Head are also used to increase and distribute breeder seed and seed of new cultivars of cereal, forage, oilseed, and pulse crops developed by the Branch.

Only a portion of the results are reported here. More can be obtained from the scientists at the following address: Research Station, Agriculture Canada, 5000 Wascana Parkway, P.O. Box 440, Regina, Sask. S4P 3A2.

J. R. Hay  
Director

## BIOLOGICAL CONTROL

The future for the biocontrol of Canada thistle depends on the acceptance of some damage to native *Cirsium* species. At present the introduced stem-mining weevil *Ceutorhynchus litura* is slowly increasing and spreading at seven localities across Canada. The weevil is widely adapted to the agricultural region of Canada, but although some stress is imposed on the thistle, it is not enough to control it. The situation with the gall fly *Urophora cardui* is similar. Although the fly is decreasing or has died out in Western Canada, it is thriving in the East. In New Brunswick, although carrying a microsporidian disease (*Nosema* sp.), it has spread over 5 km<sup>2</sup> and since its release in 1975 it attacks up to 4–15% of the thistle shoots.

However, a field experiment at Regina showed that even 13 galls per thistle shoot were insufficient to control the weed.

Additional tests on the Canada thistle leaf-feeding beetle *Lema cyanella* showed that although no crop plants were accepted, it will feed and oviposit on the native thistle *Cirsium drummondii* as readily as on Canada thistle. There are no breeding records on any species except *C. arvense* in Europe. However, our

tests suggest that some native North American *Cirsium* species may be damaged if the beetle is released in Canada.

The moth *Porphyrrinia purpurina* which is widespread in southeastern Europe is the one remaining possibility for a monophagous Canada thistle insect. There are insects in Asia that feed on other *Cirsium* species, but if they have a broad enough host range to accept Canada thistle, they will probably also accept native North American *Cirsium* species.

The perennial sow-thistle seed-head fly *Tephritis dilacerata* was released at three sites in Saskatchewan and bred satisfactorily at one. A strong colony of the leaf-gall fly *Cystiphora sonchi*, which was received from Austria, has been established in quarantine. Preliminary tests indicate that this fly attacks only *Sonchus* species.

The monophagous *Hypericum* aphid *Aphis chloris* was released on St. John's-wort near Cranbrook, B.C., to supplement other control agents that have not prevented the spread of the weed in that area. Some breeding occurred in the field before winter.

Collections of the native bindweed leaf-feeding beetles *Chirida guttata*, *Metriona purpurata*, and *Chelymorpha cassidea* were moved from Saskatchewan to Medicine Hat, Alta., to reinforce the small numbers of *M. purpurata* already there.

A small colony of the root-boring beetle *Oberea erythrocephala* was released on leafy spurge in Saskatchewan in the late fall.

Tests on the knapweed rust *Puccinia jaccatae* showed that it would survive on safflower and thus is unsuitable for use as a biocontrol agent in North America. Similarly, the leafy spurge leaf-moth *Clepsis strigana* readily accepted other plants, and so cannot be used for biocontrol.

## WEED ECOLOGY

### Weed surveys and crop losses

The fourth and final annual survey in the current series in Saskatchewan was completed on schedule. Green foxtail, wild oats, wild buckwheat, stinkweed, lamb's-quarters, red-root pigweed, and Russian thistle have been the most abundant species in each of the 4 yr. All the major grassy weed species (wild oats, green foxtail, quackgrass, Persian dandelion, and barnyard grass) were recorded in a greater percentage of the fields and with a higher mean density than in 1978.

Data from the second annual weed survey in the Peace River area of British Columbia, Manitoba, Essex and Kent counties in Ontario, and Prince Edward Island were incorporated into a computer-based data file along with the Saskatchewan data. A file of approximately 11 000 fields now exists.

Weed community differences were examined in field plots that had been under different crop rotations for 22 yr on the Indian Head Experimental Farm. Green foxtail counts averaged over 1200 plants per square metre under continuous cropping while in a wheat-fallow or wheat-wheat-fallow rotation counts averaged less than one plant per square metre.

Data collected from weeded and nonweeded plots in 30 wheat fields near Regina indicated a significant relationship between yield loss of wheat and weed seedling emergence 2-4 wk after planting.

### Population biology of weeds

Since the 1950s annual applications of 2,4-D have been recommended for the control of leafy spurge in grass. In an experiment to reevaluate this practice, 2,4-D applied once during 1978 and three times during 1979 did not give adequate long-term control. The reduction in number of shoots gave the appearance of control but the root system

remained intact and uninjured by the herbicide treatments.

Field populations of bluebur were monitored throughout the growing season. The winter annual plants produced more seed than the spring germinating individuals. A greenhouse experiment with various levels of available moisture clearly demonstrated that the species can survive under a variety of conditions. Plants flowered at all moisture levels. At the lowest levels only one flower per plant was produced. At the highest moisture level hundreds of flowers per plant were present.

## WEED PHYSIOLOGY

### Growth and development of quackgrass

Foliar applications of glycine (0.3 M) to quackgrass seedlings under controlled conditions increased tillering by approximately 40%. Applications of urea were relatively ineffective. The response to glycine is of particular interest because of its structural similarity to the herbicide glyphosate which also promotes tillering in quackgrass at sublethal concentrations. The outgrowth of the lateral buds on the rhizome, which was induced by high humidity, was associated with the arrested growth and subsequent abortion of the rhizome apex.

### Translocation and effect of glyphosate

A technique was developed to investigate the translocation and effect on the quackgrass rhizome buds of foliar-applied glyphosate. Under controlled conditions, sufficient glyphosate was translocated into the rhizome in 6 h to cause severe injury to the rhizome buds. When bud growth was stimulated by increasing the N supply, the uptake by the buds of  $^{14}\text{C}$  from  $^{14}\text{C}$ -labeled glyphosate was significantly increased but the degree of bud and leaf injury was markedly reduced. The dosage required to kill the rhizome buds under growth chamber conditions (i.e. 0.2 kg/ha) is considerably smaller than the amount recommended for use in the field.

### Leafy spurge

The length and moisture content of the leafy spurge root buds both increased significantly within 24 h of the removal of the parent shoot. Fully mature leaves exerted a

marked degree of root bud inhibition. Provision of a high humidity (95–100%) released the buds from this leaf-induced inhibition and significantly increased their rate of elongation following removal of the parent shoot. This response was prevented by conditions that restricted aeration of root buds. The results support the hypothesis that competition for water between the root buds and the parent shoot is a major factor in the mechanism of bud inhibition.

#### **Wild oat dormancy**

The concentration of GA (gibberellic acid) required to give germination of 90% or higher ( $C_{max}$ ) in 10-day-imbibed dormant wild oat seeds was used to measure the depth of GA-dependent dormancy. Dormant strains of selected pure lines and  $C_{max}$  values ranging from  $4 \times 10^{-7}$  to zero. Using this technique precise, quantitative differences were established between genetically distinct strains.

#### **Control of wild oats by delayed seeding**

Field investigations were conducted to determine the effect of delayed seeding on the growth and yield of wheat, barley, and oats, as a means of minimizing yield reductions caused by wild oats. Averaged data for 4 yr from two locations showed that delaying the seeding of wheat by 10 and 20 days resulted in a yield reduction of 3 and 16% and losses per hectare of \$23 and \$97, respectively, when yield and low grades were considered. The 10 and 20 day delay in seeding barley resulted in economic losses of \$54 and \$71/ha. In some years a 10 day delay in seeding resulted in an increase in the yield of grain but the decrease in quality resulted in a decreased economic return. The loss in return varied from season to season and could not be accurately predicted at seeding time. The loss of revenue due to the practice of delayed seeding always exceeded the cost of applying the most commonly used wild oat herbicide.

#### **Persian darnel**

This weed has shown a marked increase in Saskatchewan during the last 4 yr and its occurrence is now reported in 19 out of the 42 extension districts in the province. Although it is a small weed which is rather inconspicuous in the crop, preliminary investigations indicate that it is quite competitive. Data collected over 2 yr showed that 10 plants per square metre reduced wheat yield by an

average of 7%, while 100 plants reduced yield by 17.7%.

## **HERBICIDE BEHAVIOR IN THE ENVIRONMENT**

### **Air monitoring studies**

Polyurethane foam plugs were used to collect air samples at Regina and Indian Head. A total of 120 samples were collected daily from 3 May to 5 November at each site. A clean-up procedure was developed to improve the analysis of triallate. The limit of detection was  $0.5 \text{ ng/m}^3$  ( $12.7 \text{ ng/m}^3 = 1 \text{ ppt}$  of triallate). All samples containing triallate were confirmed by the ECD and N-detection techniques and those containing high levels were further confirmed by GC-MS technique. The highest levels of triallate,  $20\text{--}100 \text{ ng/m}^3$  at Regina and  $20\text{--}60 \text{ ng/m}^3$  at Indian Head, were found during May. During the rest of the sampling period the triallate levels were in general less than  $20 \text{ ng/m}^3$  with slightly higher amounts being detected after a rainfall and in the fall after the fall treatment. After the freeze-up in early November, the triallate levels fell below the detection limit.

### **Surface runoff losses of 2,4-D**

A 4 yr study was carried out to determine the level of 2,4-D in surface runoff from spring snowmelt. The samples were collected at the Swift Current Research Station where the herbicide was applied as a fall treatment to control flixweed and stinkweed. In 1979 the maximum 2,4-D concentration in the runoff was 63 ppb, with mean concentration of 37 ppb. The total 2,4-D loss in the runoff was 8.4 g/ha, which represented 2% of the amount applied.

### **Herbicide exposure levels of ground spray operators**

Thirty-three inhalation and 33 dermal exposure samples were collected in 1978 and 1979. The herbicides sprayed included various 2,4-D formulations, MCPA, dicamba, and several mixtures of these. The concentrations of these herbicides in air during the spraying varied from 500 to  $32\,000 \text{ ng/m}^3$ . The dermal exposure levels ranged from 10 to  $730 \text{ ng/cm}^2$ . The respiratory exposure levels (based on low-activity air intake) ranged from 10 to  $14\,000 \text{ ng/h}$ . Amounts found were not correlated with the type of formulations or the types of

herbicides being sprayed. However, the operators with cabs on their tractors were exposed to consistently lower levels of herbicide than those without cabs.

### **Degradation in soils**

Soil persistence experiments conducted with ring and carboxyl-labeled  $^{14}\text{C}$ -2,4-D in three soil types confirmed the rapid breakdown of the chemical. No degradation products were detected nor did the 2,4-D become bound or conjugated to the soil fulvic or humic acid components. The presence of the fungicide Vitavax or the insecticide malathion, or a combination of the two, did not affect the rate of breakdown of 2,4-D.

### **Persistence in soils**

Work with field plots at three locations in Saskatchewan indicated that carry-over from soil treatments of EPTC, metribuzin, and propanil should not be a problem. In all cases, less than 5% of the initial applications were recovered from the soil in the fall following the spring treatments.

Loss of triallate and trifluralin from field plots was not affected by the presence of chloramben.

Where trifluralin was incorporated in soil in the fall, 50–70% was lost by the following May. These losses were considered to be a result of volatility following chemical application.

### **Herbicide residues in minor crops**

Residues of triallate did not exceed the limit of detection of the analytical methodology (25 ppb) in alfalfa or the wheat and barley companion crops. Crops were grown under both dryland and irrigation conditions.

### **Analytical methods for herbicide residues in minor crops**

Several methods were developed for the following herbicide/crop uses (the limits of detection of the analytical methods are indicated in parentheses): 2,4-D (50 ppb) in triticale; triallate (50 ppb) in triticale; bromoxynil (20 ppb) in triticale; trifluralin (20 ppb) in fababeans; and metribuzin (50 ppb) in lentils and fababeans.

## **CROP MANAGEMENT**

### **New crops**

In tests at Indian Head from 1976 to 1978, seed yield and protein content of fababeans, field peas, and lentils which were effectively inoculated were not increased by additions of nitrogen fertilizer up to 100 kg/ha. In 1979, fababeans reacted similarly but two cultivars of field peas and of lentils produced more seed when inoculated and fertilized. The fababean yield averaged 1470 kg/ha while the field pea and lentil yields increased from 810 to 1210 and 970 to 1380 kg/ha, respectively, as nitrogen was increased from 0 to 100 kg/ha. Drought, low available soil nitrogen, and an above-average amount of incorporated straw from the previous crop of wheat may have contributed to the results observed with field peas and lentils. Further research is required to relate available soil nitrogen and soil moisture to the requirements of field pea and lentil for additional nitrogen.

### **Forage crops**

Two bromegrass/alfalfa tests were established in 1977 on adjacent plots of summerfallow and stubble. Each test consisted of 10 treatments of five rates of nitrogen with bromegrass/alfalfa in the same or alternate rows. The average dry matter yield of the summerfallow area decreased from 4300 kg/ha in 1978 to 2770 kg/ha in 1979 (36%). The corresponding yields for the stubble area were 2730 and 1990 kg/ha, a decline of 27%. Yields of dry matter and density of the alfalfa have only been marginally affected by fertilizer treatments or row arrangements. However, the plots established on stubble contained more alfalfa (50 versus 39%) and in 1978 more nitrogen in the forage (2.45 versus 2.09%). Future results should have some significance with respect to the question of establishing cultivar and agronomic tests on summerfallow or stubble.

### **Analysis**

Flow injection analysis was originally proposed by Ruzicka and Hansen as a new concept in continuous flow analysis. A sample injector was built at the Experimental Farm, Indian Head, which permitted the automation of the above analysis. The automated system consists of a sampler, timer, pump, sample injector, water bath, detector, and recorder. The equipment is relatively inexpensive and

has been used successfully to analyze plant digests for nitrogen and phosphorus and soil extracts for phosphorus.

### Cereal crops

The performance of crops grown in varying cropping sequences, with and without fertilizer, have been compared over a 22 yr period at Indian Head. Unfertilized wheat grown continuously produced yields equal to that for wheat grown in fallow-wheat and fallow-wheat-wheat sequences on a per cultivated hectare basis. The addition of fertilizer supplying nitrogen at rates of 100.8 kg/ha and phosphorus at 19.4 kg/ha has increased the average yield of continuous wheat per cultivated hectare by 25.5% over wheat grown in the fallow-grain rotations. The continuous cropping of wheat has made the control of such weeds as Canada thistle and quackgrass increasingly difficult throughout recent test years. While fertilized wheat sown on stubble land produced yields comparable to fallow plantings in 1979, they have yielded an average of 807 kg/ha less over the years. Yields of unfertilized wheat on fallow, grown in a sequence including sweetclover, has produced yields equal to that for fertilized wheat on fallow in a fallow-wheat-wheat cropping sequence.

In 1979 applications of monoammonium phosphate to wheat grown on fallow in a 3 yr fallow-wheat-wheat rotation supplying phosphorus at rates of 0-23.6 kg/ha did not provide yield increases approaching the long-term averages. This lack of satisfactory crop response was largely attributed to moisture deficiencies which occurred in the 1979 growing season. While response of wheat to monoammonium phosphate has exhibited much variability over the years, additions of phosphorus at rates of 18.9 and 23.6 kg/ha has resulted in average yield increases of 5.7 and 7.2 kg/ha, respectively, over the past 35 yr period. The incorporation of barnyard manure in the fallow year at a rate of 20 t/ha has increased 1st and 2nd yr wheat yields by an average of 20.5%. The addition of phosphorus at 9.4 kg/ha increased fallow yields by a further 5%.

Local experimentation has shown that the practice of delayed seeding on fallow beyond the 2nd wk of May can significantly reduce the yield of wheat, oats, barley, and flax. Maximum yield potential can best be assured by seeding early using 11-48-0 at 88 kg/ha as a fertilizer starter. Over the past 4 yr the average yield of wheat and barley was increased by 6.4%, oats by 3.0%, and flax by 1.7% using such treatments.

The continuous cropping of clay soils to wheat, flax, and barley required substantial amounts of nitrogen and phosphates for maximum crop yields. Studies at Indian Head have shown stubble crop yields were increased an average of 273% in 1979 through the banding of nitrogen at 78.4 kg/ha and phosphorus at 44.8 kg/ha at seeding. Highest response was recorded for wheat at 1237 kg/ha, followed by flax and barley with increases of 845.6 and 478.8 kg/ha, respectively.

### SEED INCREASE AND DISTRIBUTION

In 1979, Agriculture Canada released to SeCan 175 800 kg of Benito wheat, 2028 kg of Bedford barley, and 376 kg of Cascade oats, which were increased at Regina. Seed of the new hybrid sunflower CMH 101 was produced at Regina and released to the seed trade. Breeder seed of 44 cultivars of cereal and oilseed crops was released to 262 growers.

The 6.7 ha winter increase nursery in California was used by 32 breeders. This is a small increase in size from last year. A new power seeder using seed tray cassettes was successfully built to improve the efficiency of the planting operation in California.

In 1979 the 4201 samples collected by the Food Production and Inspection Branch and by the Canadian Seed Growers Association were grown for verification of purity. The results show a continued reduction in the number of samples with contamination, and a general improvement of purity. A few varieties continue to contain a higher than average amount of off-types but these are being reduced as the purified breeder seed works through the system.

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# Research Station

## Saskatoon, Saskatchewan

### PROFESSIONAL STAFF

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R. J. PETERS	Assistant Administrative Officer
E. J. WATSON <sup>1</sup>	Assistant Librarian
H. K. MILNE	Computer Systems Programmer
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### Plant Breeding and Agronomy

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R. P. KNOWLES, B.S.A., M.Sc., Ph.D., F.A.I.C.	Grass breeding
G. L. LEES, B.Sc., Ph.D.	Legume bloat: plant physiology
D. I. MCGREGOR, B.Sc., M.Sc., Ph.D.	Physiology of <i>Brassica</i> spp.
L. G. SONMOR, B.S.A., M.Sc.	Irrigation
G. R. STRINGAM, B.S., M.S., Ph.D.	Cytogenetics of <i>Brassica</i> spp.
H. UKRAINETZ, B.S.A.	Soil fertility
D. L. WOODS, B.Pharm., M.Phil., Ph.D.	Oilseed breeding: mustard, sunflowers

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C. H. CRAIG, B.A.	Forage crop insects
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J. F. DOANE, B.S.A., M.S., Ph.D.	Insects, ecology, behavior
A. B. EWEN, B.A., M.A., Ph.D., F.R.E.S.	Insects, ecology, pathology
R. J. FORD, B.S.A., M.Sc., Ph.D.	Engineering
F. J. H. FREDEEN, B.S.A., M.Sc.	Black flies
L. B. HAYLES, <sup>2</sup> D.V.M. & S., Ph.D., M.R.C.V.S.	Mosquitoes and arboviruses
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K. S. MCKINLAY, B.Sc.	Pesticides, toxicology
M. K. MUKERJI, B.Sc., M.Sc., Ph.D.	Insects, management
O. O. OLFERT, B.Sc., B.S.A., M.Sc., Ph.D.	Insects, ecology
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J. DUECK, B.S.A., M.Sc., Ph.D.	Oilseed crop diseases
H. HARDING, B.Sc., Ph.D.	Cereal root diseases
G. A. PETRIE, B.A., M.A., Ph.D.	Oilseed crop diseases
J. D. SMITH, B.Sc., M.Sc.	Forage and low-temperature diseases
P. R. VERMA, B.Sc., M.Sc., Ph.D.	Cereal root diseases

## Departures

J. C. BOYER Retired 28 December 1979	Administrative Officer
S. J. CAMPBELL, B.Sc., Ph.D. Resigned 8 September 1979	Oilseed breeding: sunflowers
J. E. R. GREENSHIELDS, B.S.A., M.Sc., Ph.D., F.A.I.C. Retired 28 December 1979	Director
A. E. MCPHERSON, B.A., B.L.S., M.A. Resigned 15 June 1979	Library Area Coordinator

## VISITING SCIENTISTS

- J. R. KING, B.Sc., Ph.D. Plant physiology  
National Research Council of Canada visiting  
fellow, 1978-1980
- S. K. RAINA, B.Sc., M.Sc., Ph.D. Insect physiology  
Rotary Foundation Fellow, 1977;  
National Research Council of Canada visiting  
fellow, 1978-1980

### *Graduate students*

- D. DOSTALER, B.Sc., M.Sc. Plant pathology  
D. S. HUTCHESON, B.A., B.S.A. Plant breeding  
C. S. SAHA, M.Ag., M.S. Plant breeding  
B. E. TOCHOR, B.S.A. Plant breeding  
C. L. VERA, Ing. Agron. Plant breeding

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<sup>1</sup>Seconded from Libraries Division, Finance and Administration Branch.

<sup>2</sup>On leave, FAO assignment to Somalia, East Africa, from 1 October 1979 to 30 September 1980.

## INTRODUCTION

Research programs at the Saskatoon Research Station and the Scott Experimental Farm emphasize yield, quality improvement, and protection of the main forage and edible oilseed crops, wheat, and barley. The ecology and control of black flies and mosquitoes are also important areas of investigation.

The elucidation of the causes of pasture bloat has resulted in the development of rapid selection techniques essential for the development of a bloat-safe alfalfa, while the release of Cree, a new winter-hardy birdsfoot trefoil cultivar, will further extend the adaptation of this nonbloating forage legume. Incorporation of resistance to the major diseases of rape and mustard into improved cultivars is proceeding rapidly, while the combined use of a microsporidian and ultralow insecticide dosage bran baits promise a new and effective system for grasshopper control.

We regret the early retirement of Dr. J. E. R. Greenshields, Director of this Station for the past 15 yr. His leadership and expertise will be greatly missed. We will also sorely miss Administrative Officer J. C. Boyer, who retired, and Area Library Coordinator Arlean McPherson and sunflower breeder Dr. S. J. Campbell, who resigned during the year.

Previous reports and reprints of publications can be obtained from the Saskatoon Research Station, Research Branch, Agriculture Canada, 107 Science Cres., Saskatoon, Sask. S7N 0X2.

R. K. Downey  
Acting Director

## CROPS

### Oilseeds

*Rapeseed breeding.* The changeover to low erucic, low glucosinolate rapeseed varieties is progressing favorably, with 67% of the 1979 Canadian hectareage seeded to such "double low" varieties. The *Brassica campestris* L. variety Candle, released from the Saskatoon Station in 1977, occupied approximately 800 000 ha or 25.3% of the total rapeseed hectareage.

A number of promising double low *B. campestris* strains evaluated in cooperative trials were superior to Candle in seed yield and oil content. Several of these also have genetic resistance to race 7 of white rust, *Albugo candida* (Pers. ex Lév.) Ktze. They represent potential replacements for Candle if their performance continues to be superior in 1980 tests.

Pure yellow-seeded, double low *B. campestris* strains have been developed through a greenhouse crossing program. They were similar in yield to the yellow brown strains from which they were developed and equal or superior to them in oil content.

Seed stocks of one *B. napus* L. and three *B. campestris* strains with high erucic acid oil

and low glucosinolate meal are being multiplied in California. The *B. napus* strain has 44.3% erucic and 0.7 mg glucosinolates, while the *B. campestris* strains range from 49.5 to 51.7% erucic and 2.3 to 3.8 mg glucosinolates. Selection with the aid of bud analysis was successful in reducing glucosinolate level in high erucic *B. campestris* strains to less than 1 mg.

An interspecific crossing program designed to transfer earliness from *B. campestris* to *B. napus* has produced several double low, advanced generation *B. napus* lines which are earlier than any present *B. napus* cultivars, and up to 10% higher yielding.

*Natural abortion in rapeseed.* Studies of the sequence and pattern of flower production in *B. napus* and *B. campestris* have shown that a considerable number of buds and flowers abort rather than produce seed-bearing pods. This natural abortion may exceed 50% of the number of flowers that open. Abortion occurs predominantly toward the end of flowering, or after, and is most prevalent on late-developing inflorescences. Retention of some of the buds, flowers, or pods that otherwise would have aborted is at least a partial explanation why rapeseed is

able to recover quickly from hailstorms, often with little loss of harvestable seed.

*Isolation distances for seed rape production.* Field trials have determined the effectiveness of isolation distance in preventing cross-contamination in *B. napus*. Using the 1973 Canadian Seed Growers' Association regulations for isolation distance in pedigreed seed production as a guide, plots for a *B. napus* strain containing a recessive genetic marker were sown to determine the relative amount of pollen contamination from adjacent fields. Average contamination levels from five tests over 4 yr were 2.1, 1.1, and 0.6% at isolation distances of 46, 137, and 366 m. These contamination levels are considerably lower than reported previously for *B. campestris*. The data indicate that different isolation requirements for pedigreed seed production should be considered for *B. napus* and *B. campestris*.

*Mustard breeding and management.* Four lines of yellow mustard yielding 10% more than existing licensed cultivars have been identified. Advanced lines of high oil, high erucic acid yellow mustard have also been identified; all have exceeded Sabre in yield while containing at least 2% more oil. High erucic yellow mustard oil is used as an industrial oil source in the USA, but so far not in Canada.

Time of swathing experiments have been conducted at Saskatoon on both mustard species over a 4 yr period. Early swathing, when seeds contained about 45% moisture, resulted in a significant lowering of seed yields but did not affect the incidence of green seeds or the level of glucosinolates. Reduced yields are largely attributable to small seed size. Highest yield and quality resulted when fields were swathed with seed moistures of less than 30%.

## Grasses

*Selection of brome grass for better regrowth characteristics.* Smooth brome grass, *Bromus inermis* Leyss., has a reputation of slow regrowth following a hay harvest. Under a two- or three-cut per season schedule, as used for brome grass-alfalfa mixtures, this results in little grass in the mixture in later cuts. Where second growth is used for pasture it results in predominantly legume regrowth and increased danger of bloat. Thus, interspecific crosses were made to introduce the more rapid recovery of meadow brome grass,

*Bromus riparius* Rehm, into smooth brome grass. A group of 43 F<sub>1</sub>, F<sub>2</sub>, and F<sub>3</sub> plants from crosses of meadow brome grass × smooth brome grass were selected for recovery in the fall of 1978. During the winter of 1978-1979 these plants were allowed to intercross to allow further selection. Following clipping and seed harvest in the greenhouse, an 18 cm pot of each plant was clipped monthly at a 2.5 cm level until August. Eighteen smooth brome grass plants were clipped in a similar manner. Total pot yields of clippings for a 5 mo period varied from 6.7 to 15.9 g per pot for crosses compared to 2.7 to 10.0 g for smooth brome grass. The considerable range of regrowth for hybrids suggests that this may be a useful method of breeding a better recovery brome grass.

## Legumes

*Pasture bloat in cattle.* Certain legume forage crops cause pasture bloat because they are digested very rapidly, while bloat-safe legumes are digested more slowly (see *Canada Agriculture* 24(3):6-9; 1979). On the basis of this knowledge we are selecting two strains of alfalfa, one with a slow rate of digestion and the other with a fast rate of digestion. The slow strain is expected to have lower bloat potency, and is intended to form the basis of a new, bloat-safe alfalfa cultivar. First-generation plants of the fast and slow strains have been selected using a modified nylon bag technique in fistulated cattle. Although this modified technique has been very useful in demonstrating that alfalfa genotypes differ in their initial rates of digestion, it is a time-consuming technique. Therefore, we have continued the development of faster, simpler techniques for use in breeding a bloat-safe alfalfa variety.

The most promising new technique is based upon the rate of leaf tissue digestion by a purified enzyme which selectively degrades the pectin constituent of the leaf tissue. Discs of leaf tissue are incubated with pectinase enzyme and the area of pectin digestion is subsequently revealed by staining with a pectin-specific stain. Because the technique requires only a few leaves, it can be applied to seedling plants, thus greatly reducing the cost of screening large numbers of plants.

An alternative approach is to select plants which have greater mechanical strength of leaf tissues. This approach is based on the premise that leaves which are more resistant

to mechanical damage will have less bloat potency. Leaves are disrupted with an ultrasonic sonifier and the amount of chlorophyll released is used to measure the extent of leaf damage. These new techniques are being applied to the development of new alfalfa strains from agronomically superior varieties. The new strains will be tested for bloat potency in cattle-feeding trials.

*Birdsfoot trefoil breeding.* Cree, a winter-hardy cultivar of birdsfoot trefoil developed at Saskatoon, was licensed in 1979. It is the first trefoil cultivar bred in Western Canada. This breeding project started in 1950 and involved several generations of selection for increased winterhardiness and superior agronomic traits, such as high forage and seed yields and seedling vigor. Extensive performance testing was carried out from 1960 to 1975 throughout the Prairie Provinces and British Columbia. These tests showed Cree to be more winter-hardy and approximately 15% higher in forage and seed yield than the standard Empire cultivar. In comparison with the recently licensed Eastern Canadian cultivar Leo, Cree is equal to Leo in hardiness and forage yield, but it is higher in seed yield and has excellent seedling vigor. Cree will probably find its greatest use where alfalfa cannot be grown because of inadequate drainage or excess acidity and when bloat is a problem. Seeds Canada (SeCan) is responsible for seed increase and distribution of Cree.

## Cereals

*Wheat breeding.* This program has concentrated on the identification of high-yielding, readily identifiable utility-type wheat strains. Advanced Saskatoon breeding material now included or ready for inclusion in the non-bread cooperative wheat trials has been selected for medium grain quality and white or nearly white seed color.

## Agronomy and weed control

*Effect of tillage, fertilizer, and seeding date on yield of cereals.* Combined tillage, fertilizer, and date of seeding treatments for wheat production on Gray Wooded soils have indicated that a 10 day delay in seeding from early to mid-May results in an 8% yield reduction. Delayed seeding also reduced volume weight, which led to grade reductions in at least 3 of the 20 yr of testing. Fertilizer (N at 6 kg and P at 27 kg/ha) increased

yields by 20% and hastened maturity, particularly for the late-seeded treatments. Packing either before or after seeding did not affect wheat yields significantly, nor did harrowing 3–5 days after seeding.

Fall tillage treatments applied to wheat stubble on Gray Wooded soil led to moderate yield increases in the succeeding barley crop. Nitrogen applied in the fall at 22.5 kg/ha increased yields by 39% over the past 8 yr. Subsoiling increased spring soil moisture levels over the untreated check, whereas tillage treatments which bury the stubble, such as double discing or tilling with a rotary cultivator, reduced soil moisture the following spring. Highest yields were obtained with the combination of subsoiling and fertilizing.

*Effects of date of seeding and phosphate fertilizer on sunflowers.* The sunflower cultivar Saturn was seeded on Scott loam fallow on five successive dates (11, 15, 18, 23, and 30 May 1978) with and without P at 19.7 kg/ha as a side band application. Soil temperatures at seed depth reached 4.4°C on 20 May and remained above this level except for slight decreases on two nights in early June.

Highest seed yield without fertilizer was obtained from the earliest seeding, but the highest fertilized yield and largest yield increase (580 kg/ha) from phosphate fertilizer were obtained from the 18 May seeding. The phosphate fertilizer advanced flowering of the crop by 4–6 days, and increased mature height of plants by 3.3–11.7 cm. Seed oil content was not affected by phosphate fertilizer on the first two dates of seeding in 1979, but percent oil decreased for the last three seeding dates without fertilizer, and phosphate fertilizer maintained oil levels higher than in the checks.

*Effects of nitrogen source, rate, and placement for crops on stubble land.* On a Black Waseca loam soil having very low available N, but under good moisture conditions, Neepawa wheat responded to rates of N up to 180 kg/ha, giving a yield increase of 2365 kg/ha (210%). With the same rates of applied N, but under less favorable growing conditions on a Gray Luvisol Loon River loam, maximum increases of Bonanza barley and Candle rapeseed were less, amounting to 1418 kg/ha (60%) and 828 kg/ha (128%). Data showed that adequate phosphate was required for maximum response to nitrogen.

There were no significant differences among nitrogen sources or methods of application on Waseca soil when ammonium nitrate or urea was broadcast or side banded with wheat, barley, and rapeseed. However, on the Loon River soil, having low organic matter and cation exchange capacity, urea produced lower yields than ammonium nitrate. Side banding urea supplying N at rates above 45 kg/ha on Loon River soil sharply reduced yields of barley and rapeseed, indicating that a 4 cm separation of seed and urea fertilizer in this soil was not sufficient to prevent fertilizer phytotoxicity.

*Weed control.* The efficacy of six herbicides for the control of the wild oat (*Avena fatua* L.) was compared in wheat, 1976–1979, at Scott and Saskatoon. All six herbicides (barban, triallate, benzoilprop-ethyl, difenzoquat, diclofop-methyl, and flamprop-methyl) produced wheat yield increases over the course of the study. However, yield increases tended to be greater in years when wild oat populations were highest. Yield increases obtained from applying a herbicide ranged from 8 to 24%, with diclofop-methyl consistently producing the largest increase. Reduction in the dry matter weight of wild oats ranged from 29 to 97%, with diclofop-methyl also producing the largest weight reductions. Competition from wild oats treated at the two-leaf stage did not reduce wheat yields when compared to the weed-free check, provided the kill obtained was rapid.

*Zero tillage.* Interest in reduced tillage or "zero" tillage farming has increased considerably in Saskatchewan in recent years. In the southwest and west-central regions, drought is always a concern and summerfallow is used extensively to reduce the risks associated with extended crop rotations. At Scott, chemical fallow (no soil disturbance) has been investigated extensively as a possible replacement for conventional tillage fallow. The advantages observed for chemical fallow have been: equal or improved weed control, elimination of wind erosion, increased moisture conservation, reduced energy costs, and equal or improved yields of succeeding crops. The major disadvantage, however, is cost, which at present is approximately three times that of tillage fallow.

## PLANT DISEASES

### Diseases of oilseeds

*Blackleg of rapeseed.* The virulent strain of blackleg (*Leptosphaeria maculans* (Desm.) Ces. & de Not.) was found for the first time on rapeseed in northwestern Saskatchewan in 1979. This represents a considerable extension of the area of occurrence of this potentially serious disease. Previously, it was present in east-central and northeastern districts. However, although the disease was prevalent late in the growing season, occurring in 55% of Saskatchewan fields sampled, it was present only in 18% of those entered in midsummer, and then usually only in slight amounts. Such a late-season buildup of the disease, of little significance from a yield loss standpoint in the current year's crop, has been noted for several years. Data from a 4 yr study of seasonal ascospore discharge patterns of the fungus indicate that most spores are released after the crop has passed its stage of greatest susceptibility to infection. It follows that if there is little deviation from the sporulation patterns observed to date, blackleg should not be as severe a disease in Canada as it is in countries such as Australia where ascospores are liberated and cause infection throughout most, if not all, of the year.

*Rhizoctonia diseases of rapeseed.* Rhizoctonia damping-off, seedling blight, and foot rot have caused some concern in Saskatchewan in recent years. In 1979, Rhizoctonia was present in 95% of fields sampled late in the season. In the spring, the seedling phase of this disease was severe and many farmers resowed their rape fields. Screening for resistance to *Rhizoctonia* has proceeded in conjunction with screening for blackleg resistance. A number of lines resistant to both diseases have been identified.

*White rust of rapeseed.* Breeding lines of *B. campestris* resistant to race 7 of white rust are now in an advanced stage of development and were included in the cooperative rapeseed and rape strain tests in 1979. Incorporation of resistance to race 2 of this disease into agronomically desirable cultivars of *B. juncea* (L.) Coss. is also progressing satisfactorily.

The staghead phase of white rust was controlled effectively on the cultivar Torch by a single application of the fungicide Ridomil (Ciba-Geigy) supplying active ingredient (a.i.) at 0.4 kg/ha when sprayed at crop stage

3.2. A study of the metabolism of this fungicide in rape plants is under way. Two of its metabolites have been partially purified but require further purification before they can be chemically identified.

*Sclerotinia stem rot of rapeseed.* A pre-plant incorporation into soil of *Coniothyrium minitans* Campbell, which is a hyperparasite of *Sclerotinia sclerotiorum* (Lib.) de Bary, reduced incidence of stem rot of rape by 50% when conditions favored a moderate disease outbreak. Under highly favorable disease conditions the application of *C. minitans* was ineffective as a biological control. At one naturally infested location the number of sclerotia of *S. sclerotiorum* in soil declined by 70% over summer in the absence of a host crop.

*Resistance of rapeseed and sunflower to Sclerotinia.* Two selections from the sunflower inbred HA61 showed a moderate level of resistance to *Sclerotinia*. For rapeseed, an ascospore growth-room inoculation technique was developed which simulates conditions of natural infection. The technique will assist in evaluating lines for resistance.

#### Diseases of cereals

*Common root rot.* In 1979, the estimated loss from the disease in red spring wheat in Saskatchewan was 5.5%. This value is considerably higher than that for 1978 (2.9%), but below the average of 7.4% for 1969–1978.

In the recurrent selection program for superior resistance in wheat, selections were made among some 2300 lines of the F<sub>4</sub> or F<sub>5</sub> generations from crosses between fairly resistant parents. Selection commenced in the F<sub>3</sub> generation. The frequency of lines showing good potential was considerably higher in the F<sub>5</sub> than F<sub>4</sub> material. Some 1200 barley lines were screened and about 14% were saved for further testing since they appeared less diseased than Bonanza. Of 19 lines that had performed well in 2 or 3 yr of testing, 14 continued to display higher resistance than Bonanza.

On acid loam, fallow soil at Scott the intensity of root rot in Neepawa wheat was little affected by N or P fertilizer with the seed but it was consistently, though only slightly, reduced by the application of K with N and P. The test was conducted in each of 6 yr.

Over 90% of conidia of *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur, the

major cause of common root rot in the prairies, were found in the top 10 cm of soil in commercial fields. Where minimum tillage was practiced, over 90% of the conidia were in the top 5 cm of soil, while in plowed soils, conidia were almost evenly distributed throughout the top 20 cm, and were commonly found in the 20–30 cm profile.

Seed treatment with the systemic fungicide imazalil, EL 228 (Elanco), Bayleton (Chemagro), Baytan (Chemagro), or RH 2161 (Rohm & Haas) at rates supplying the active ingredient below 1 g/kg seed significantly reduced the incidence and severity of common root rot in Cypress and Neepawa wheat in field tests. A dosage response was evident in disease suppression. Treatment effects on yield, however, were inconclusive.

Morphological changes such as shortening and thickening of subcrown internodes, and formation of deeper crowns and coleoptile-node-tillers were induced by all five fungicides. Of 22 seed treatments tested, only those containing EL 228, RH 2161, and Baytan reduced common root rot of Galt barley but this was not accompanied by a significant yield increase over the nontreated control.

Attempts were made to improve the toxin-producing capacity of two morphologically distinct isolates of *C. sativus*. Toxin production was assayed by the degree of inhibition of seed germination of Neepawa and Little Club wheat. Single spore and mass transfer series were established and after each generation the best toxin-producing culture was selected. From this culture 10 single spores or 10 mass transfers were made and the process of selection was repeated. After 16 to 20 generations no increase in toxin production has been recorded. Toxin production decreased somewhat in the mass-transfer series but it appears to have stabilized at this lower level. No changes in colony morphology have become apparent during this period of time.

Several hundred isolates of *C. sativus* were categorized on the basis of colony morphology, mating type, and toxin production to study the range of variation in the fungus. Four new spore-color mutants were isolated and a total of 29 spore-color mutants were tested for pathogenicity, toxin production, colony morphology, and mating type. All produced lesions on subcrown internodes of Neepawa wheat, although there were marked differences in virulence. There was a similar range in toxin-producing capacity. There was



a wide range of colony types as determined on a series of differential media based on 20 different protein hydrolysate preparations. Both mating types were represented: 11 of type A and 18 of type a.

A 2000-citation bibliography of *C. sativus* has been compiled and made computer-accessible with the FAMULUS program.

*Low-temperature diseases.* At Saskatoon, severe *Sclerotinia borealis* Bub. & Vleug. snow mold was induced in Cougar fall rye plots by inoculation with cultures of the fungus grown on sterile rye grain and trapping of snow with fences. One fall application of quintozone fungicide supplying active ingredient at 5 kg/ha increased plant survival by nearly 100% and grain yield about 80%. In a similar test with Sundance winter wheat, plant survival was increased about 50% by the fungicide but the crop yield was not significantly affected. Similar results were obtained in previous years. Apparently, a sizable reduction in plant number may be sustained by winter cereals before there is a significant yield loss. This is probably because surviving plants compensate to a considerable degree for the killed plants. It is quite characteristic that after frost and disease injury, plot areas of winter wheat which recover are later in ripening than undamaged portions.

*Plenodomus meliloti* Dearness & Sandford was recorded for the first time on cereals in Canada in 1979. Its protopycnidia were abundant on winter wheat plants showing severe winter injury collected at Lacombe and Three Hills, Alta., and several locations in Saskatchewan. The structures occurred on the shoot bases and along roots to a depth of 10 cm. The fungus was also found on fall rye and winterkilled red clover and alfalfa in Saskatchewan. It had been collected from snow mold damaged turfgrass in Western Canada in 1972, but not identified. On many of the dead wheat plants bearing it, the sclerotia of the sclerotial low-temperature basidiomycete (SLTB) were abundant, mainly on the shoot bases. The SLTB is a common snow mold pathogen of turfgrasses and some forage grasses in Western Canada, but is less active than the nonsclerotial low-temperature basidiomycete (LTB). *Plenodomus*, the SLTB, and low-temperature-tolerant *Fusarium* spp. were isolated from dead alfalfa crowns in Saskatchewan in the spring of 1979, but the LTB was not found to be involved. This raises doubts about whether the latter pathogen,

which is important in alfalfa snow mold damage in parts of Alberta, is of similar importance in Saskatchewan.

Fungi active at temperatures a few degrees above the freezing point may be of importance in killing or injuring winter cereals in spring which have already been damaged by frost or snow molds that tolerate lower temperatures. To obtain data on which groups of fungi might be involved, spring rye, wheat, and barley seed was treated with three fungicidal seed dressings with different spectra of activity and sown so late in the fall of 1978 that they did not germinate until the spring of 1979. In this way, the cereals would largely avoid attacks by snow molds but would be exposed to fungi active in early spring. However, there was no significant improvement in plant stand or crop yield from the treatments compared with the controls. The results suggest two alternative situations: (a) that there was little fungal injury, (b) the fungicides applied as seed dressings had little effect; this is a general experience of fungicidal seed dressings applied to control snow molds. Fungicides that are intended to be used to control pathogens attacking damaged cereals in spring may be more effective applied as sprays at that time, in the same manner as those used to control snow molds before winter.

Complexes of snow molds are known to be important in killing winter cereals in snowy years in Western Canada. The same pathogens found in the West were noted on winter wheat in southern Ontario in cooperative disease surveys with the Ottawa Research Station. *Sclerotinia borealis*, *Typhula ishikariensis* Imai. var. *canadensis* Smith & Årsvoll, *T. incarnata* Lasch ex Fries and *F. nivale* (Fr.) Ces. were present, but much of the winter injury was due to low-temperature killing.

## ENTOMOLOGY

### Oilseed insects

*Flea beetles.* Two additional crucifer-feeding flea beetles from the province were identified, one being *P. bipustulata* (F.), and the other a new species currently being described in the USA. A nondirectional sticky trap was developed that proved effective in flight studies in the forest. Three factors affecting the rate of allyl isothiocyanate release from attractant traps were identified

and measured, making possible reduction of variation in release rates between traps.

In small-plot trials during 1978 and 1979, where rape seedlings were under flea beetle attack from emergence onward, yields of the rapeseed cultivars Tower, Torch, and Candle were consistently higher in stands grown from seed planted with carbofuran granules (in-furrow treatment) than those in stands grown from seed treated with lindane powder seed dressings. Though the carbofuran in-furrow treatments cost more per unit of planted crop than the lindane seed treatments, the value of the yield increase in each case markedly exceeded the difference in cost. The lindane powder seed treatments did increase yields significantly over no protection at all, and gave better protection when the powder was applied to seed first coated with vegetable oil than when applied to dry seed. Increased yield with both insecticides reflected, in general, increased numbers and growth of surviving seedlings and, in some cases, earlier bloom. The treatments did not affect, however, the weights of individual harvested seeds or their oil content.

Analysis of seedlings from lindane-treated seed sown in the 1978 and 1979 trials showed that more lindane is present in seedlings grown from seed treated with oil prior to application of lindane powder than in seedlings grown from dry-treated seed. Methods of determining carbofuran levels in rape seedlings have been developed and analysis for this insecticide in the 1978 and 1979 samples is in progress.

*Bertha armyworm.* Larval surveys showed that bertha armyworm populations in Saskatchewan were above economic levels for the first time since the early 1970s, with significant infestations being found in a few rape fields in northeastern and central Saskatchewan. It appeared that the pheromone traps for monitoring bertha moths gave a clearer indication of this impending increase in populations than did the light trap monitoring network. There is a distinct possibility that serious outbreaks of this pest may occur in 1980 or 1981.

*Sunflower moth.* The dates of arrival of sunflower moths in Saskatchewan were monitored with pheromone traps baited with virgin female moths or with a synthetic pheromone. Five weather systems were found to have been responsible for bringing the adult moths into Saskatchewan from the United States. Two of

the five moth arrival dates had been predicted from weather forecast data by Dr. J. D. Bauer of the Atmospheric Environmental Service in Saskatoon. As most of the adult moths arrived several weeks before sunflower blooming, the moths did not lay their eggs on the cultivated sunflower crop, and no economic larval infestations were recorded.

## Grasshoppers

*Biological control.* A study of the effectiveness of a microsporidian, *Nosema locustae* Canning, as a control agent against grasshoppers in Saskatchewan revealed that 50% of the migratory, Packard, and clearwinged grasshoppers were infected between 4 and 5 wk after application of the pathogen. Maximums of 95–100% infection were evident between 9 and 12 wk after application. Among those grasshoppers that did not die of natural causes, the population of the migratory grasshopper was reduced about 20% by the 4th wk after inoculation, about 50% by the 9th wk, and a maximum of about 60% by the 12th wk. Although there was a relationship between percentage infection and population reduction in all three species, similar percentage infection resulted in different percentage reduction in the different species. The populations of the migratory and Packard grasshoppers experienced significantly greater reduction due to the pathogen than did the population of the clearwinged grasshopper. Also, egg production in the migratory and Packard grasshoppers in treated plots was significantly lower than in untreated plots. Analysis of data also showed that the pathogen can survive the winter and infect next year's populations. Sampling in 1979 of 1978 *N. locustae* applications showed that about 60% of the migratory, 80% of the Packard, and 35% of the clearwinged grasshopper populations were infected.

*Effectiveness as a control measure of bran bait treated with ultralow dosages of insecticides.* Field application to spring wheat of treated wheat bran at 1.68–2.24 kg/ha, containing 32–42 g a.i. of dimethoate or 2.5–3.3 g a.i. of Belmark (Shell), reduced the population of third and fourth instar grasshoppers by 40–50% within 24 h. The reduction reached a maximum within 5 days of application. Doubling the amount of bran applied per hectare without changing the amount of dimethoate applied per hectare did not significantly increase effectiveness as

evidenced by the mortality of fourth and fifth instar grasshoppers.

Application of treated bran at 8.9 kg/ha, containing 137 g a.i. of dimethoate, on adult grasshoppers infesting alfalfa seed fields reduced the population by 70% within 24 h and 90% within 5 days. By comparison, the currently recommended dosage of active ingredient of liquid dimethoate formulation for grasshopper control in alfalfa is approximately 210–420 g/ha. Thus the use of insecticide-treated bran bait for grasshopper control has potential advantages in jointly reducing the amount of insecticide used and the hazard to the environment.

### Wireworms

*A trap for larvae.* A trap has been developed that will attract and retain wireworm larvae. This subterranean trap makes use of the attractiveness to larvae of CO<sub>2</sub> given off by germinating seeds, and is designed so that larvae in the soil encounter and move through soil between two plexiglass disks held a few centimetres apart, and then enter a bait chamber from which they are unable to escape. Germinating sunflower or wheat seeds in the soil-filled bait chamber are used as bait. In use, the trap is buried about 7 cm below the soil surface and checked for catches at 2 wk intervals. This trap has proved useful for survey and detection of wireworm larvae and investigation of seasonal activity and feeding behavior. Traps of this design have been successful in capturing larvae of four wireworm species, the prairie grain wireworm, the sugarbeet wireworm, *Hypolithus bicolor* Eschscholtz, and *Aeolus mellillus* (Say), from cultivated and noncultivated areas. The traps were generally much more effective than baits in trapping wireworms, and more effective for the prairie grain wireworm than for *H. bicolor*. An unbaited trap captured very few larvae, showing that larvae enter the trap in response to the attractant rather than to physical stimuli.

### Forage crop insects

*Integrated control.* For the second consecutive year euphorine parasites of European species of plant bugs of the genus *Lygus* were received at Saskatoon from the Swiss laboratory of the Commonwealth Institute of Biological Control via Research Program Service. These parasites were released into alfalfa

seed fields at Rolling Hills in the short-grass prairie of southern Alberta, and at Shellbrook in the north-central agricultural parkland of Saskatchewan. Prior to the releases, the incidence of indigenous euphorine parasitism was found to be 15% in the *Lygus* population and 0% in the alfalfa plant bug population at Rolling Hills, and 19% and 24% at Shellbrook. The 24% incidence of euphorine parasitism in the alfalfa plant bug population at Shellbrook is noteworthy as the highest (normally about 3%) ever recorded for this host in Western Canada.

At the Moose Jaw site where introduced parasites were released in 1978, 29% of the *Lygus* nymphal population was found to be parasitized in 1979. This compares to a prerelease incidence of 33%. At present the identity of the parasites in the 1979 *Lygus* population is not known. Part of a sample of parasite cocoons obtained from the 1978 release sites at Moose Jaw and Saskatoon yielded no adult parasites when subjected to continuous rearing conditions. The remainder of the sample is receiving treatments conducive to termination of a probable pupal diapause.

### Black flies

*Environmental effects of injecting methoxychlor black-fly larvicide into large rivers.* Since 1968 methoxychlor black-fly larvicide (24% EC) has been injected, generally at the rate of 0.3 ppm sustained for 15 min, into either one or both branches of the Saskatchewan River in Saskatchewan, on one or more occasions every year.

Control of *Simulium arcticum* Mall., a multivoltine species with one major and one or more minor cycles per summer, generally could be achieved with one or two springtime injections. About 1976, *S. luggeri* N. & M. became the dominant species. This also is multivoltine but capable of repeated major cycles each summer; it is not controllable with springtime injections alone. Thus the larvicide test program has been steadily intensified since 1976. Only in 1979 was it intensive enough, with one to five injections in each of eight sites, to prevent massive, summer-long outbreaks. Outbreaks in 1976 to 1978 inclusive caused considerable financial losses to livestock owners and extreme discomfort to people in rural and urban areas 10 000 to

30 000 km<sup>2</sup> in size in east-central Saskatchewan.

Despite the increasingly intensive larviciding program, sports fish and minnows have remained abundant and populations of non-target invertebrates have increased rather than decreased. Numbers of Ephemeroptera and Plecoptera attaching weekly to artificial substrates in the North Saskatchewan River near Cecil were more than 15 times larger in 1979 than in 1970; Trichoptera were about six times more abundant and Chironomidae 90 times more abundant.

In the South Saskatchewan River near Birch Hills during the past 3 yr Ephemeroptera and Trichoptera more than doubled in numbers; Plecoptera and Chironomidae remained unchanged. In the main Saskatchewan River near Gronlid during the past 3 yr all major taxa increased by factors of two to over four times.

Surber-net collections from the beds of both rivers near their confluence in August 1977, 1978, and 1979 similarly showed increases in total populations of all taxa combined, from 22 330 in 1977 to 61 536 in 1979, and in numbers of taxa from 22 to 32.

### Mosquitoes

*Arboviruses.* In Saskatchewan, mosquito populations were below the long-term average in 1977, but the number of western equine encephalomyelitis (WEE) virus isolations from mosquitoes was the highest in a number of years. Forty-seven suspect cases of the disease were recorded from horses, but none from humans. Evidently the population of the principal vector, the mosquito *Culex tarsalis* (Coq.), was too low to support a human epidemic. In 1978, the opposite situation occurred. The *C. tarsalis* population was the highest recorded in 15 yr, and large enough to support a human epidemic, but for some reason the circulation level of the virus in nature was too low, and no suspect human or horse cases were recorded. In 1979, mosquito populations, including *C. tarsalis*, were below long-term means, probably because of a late spring, dry summer, and mid-August frosts. A moderate level of arbovirus circulation in mosquitoes was indicated in 1979 by 12 virus

isolations, two of which were tentatively identified as WEE virus.

Two recent findings will be of help in determining the role of mosquitoes in winter survival of WEE virus. The first is the discovery of a number of sites where certain mosquitoes overwinter; the second is that infected females of *Culiseta inornata* (Will.) can pass a virus called Cache Valley virus to their progeny, and a continuous virus cycle can thus occur in mosquitoes without involvement of any vertebrate hosts.

### Insect nutrition

*Protein evaluation.* Although larvae of the yellow mealworm have been shown to require the same 10 essential amino acids as higher organisms, interpretation of protein quality studies has been impaired by lack of knowledge concerning their quantitative amino acid requirements. A preliminary study was completed to determine the growth response of larvae of the yellow mealworm to graded levels of essential and semiessential amino acids. Each of 14 amino acids was tested individually at levels of 0, 10, 20, 50, 100, and 200% of the amount found in larval tissues, while the concentration of other amino acids remained constant. Maximum fresh-weight gains and dry weights were obtained with larvae fed 100% of the amount in larval tissues of all essential amino acids, except phenylalanine, threonine, and tryptophan. Maximum growth was achieved by larvae fed diets containing 50% of the phenylalanine level found in larval tissues; however, the larvae apparently required more than twice the concentration of threonine and tryptophan occurring in larval tissues.

### Pesticide chemistry

*Residues of endosulfan on sunflowers.* The sunflower cultivars Corona and Commander were sprayed with endosulfan to control sunflower head moth 6 wk prior to harvest. Using a new method developed at Saskatoon, the mature seeds were chemically analyzed for endosulfan residues. Seed of both cultivars was found to contain very low levels of 0.01 ppm each of  $\alpha$ - and  $\beta$ -endosulfan and endosulfan sulfate.

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# Research Station

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## INTRODUCTION

The diversified program of research at the Swift Current Research Station emphasizes the improvement of cultivars of cereal and forage crops and the development of technology to improve production and utilization practices. This is accomplished through a multidisciplinary approach to research in plant breeding, plant physiology, agronomy, soil and water management, salinity control, nutrition, agrometeorology, and agricultural engineering.

During 1979, several potential new cultivars of cereal and forage crops progressed through various levels of testing. Optimum rates of fertilization were established for cereal and forage crops, and the most productive grazing patterns and row spacings were identified for hay and pasture crops. Rapeseed meal proved to be a cost-effective ingredient for turkey diets that feature maximum rates of gain at least cost to producers. Data were assembled to develop comprehensive models of crop production that utilize meteorological information together with soil and crop growth parameters. Factors that cause poor seed set in cereals were identified.

These and other research accomplishments are described briefly in this report. More detailed information may be obtained from the publications listed at the end of this report, from P. I. Myhr, or from individual scientists. Requests and correspondence should be addressed: Research Station, Research Branch, Agriculture Canada, Box 1030, Swift Current, Sask. S9H 3X2.

W. L. Pelton  
Director

## CEREAL PRODUCTION AND UTILIZATION

### Carbohydrate patterns in dryland wheat

For a number of years we have been measuring the levels of nonstructural carbohydrates (NSC) found in the leaves, stems, and heads of wheat plants grown under dryland field conditions. The NSC consist of short-chain carbohydrates which are extracted with ethanol and longer-chained carbohydrates which are extracted with water.

The NSC levels found in green leaves remain relatively low (<10%) throughout the growing season except for a slight increase during grain maturation; this increase probably results from the presence of fewer green leaves to fulfill the photosynthate demand of the head. The major carbohydrate present in the leaf extracts was sucrose. These results indicate that short-chain sugars do not play a major role in osmoregulation in wheat leaves.

Wheat stems exhibit a dramatic increase in NSC during the season and reach a maximum approximately 2-3 wk postanthesis. The maximum levels range from 20 to 40% of the dry weight and are varietal dependent. Generally, more carbohydrate is extracted in the water fraction than in the ethanol fraction,

suggesting the presence of longer-chain carbohydrates. Gas chromatographic analysis indicates that these polysaccharides are rich in fructose units. This stem reserve may reflect the inability of the developing head (sink) to accept the high levels of photosynthate being exported from the leaves (source). The stem NSC decline very late in the growth cycle, although we have not yet established if they contribute significantly to grain yield under dryland conditions.

### Drought physiology

Eleven wheat cultivars were evaluated under field conditions for drought resistance. Three techniques were used: thermocouple psychrometry (water content), water saturation deficit (WSD), and autoporometry (diffusion rates). Pelissier and Lakota leaves were judged to be the most resistant to drought based on superior leaf-water content, low WSD, and maintenance of high transpiration rates late into kernel filling. For the six spring wheats tested, no differences occurred in moisture stress (psychrometer). Yecora, Manitou, and ACEF-125 had more severe WSD values than Pitic, Koga, or Celinogradka; these latter cultivars also maintained higher late-season transpiration rates due to superior leaf-water retention.

Eighteen durum and spring wheats were grown under dryland and irrigation to evaluate moisture relative to plant temperature and drought resistance. The leaf temperature of irrigated plants was 3–7°C lower from heading to maturity. The leaves of plants grown on dryland gradually increased in temperature with maturation until some leaves exceeded ambient air temperature. This increase in leaf temperature was inversely proportional to transpiration rates, suggesting drought resistance also has a temperature component.

### Rye breeding and genetics

RT124, a selection from the hybrid Harroch/Petkus/Dakold, has been evaluated in cooperative tests during the past 4 yr. The test data indicate that it represents an improvement over currently licensed cultivars in a number of characteristics. Winter survival has been satisfactory and in most cases RT124 was the best. During the period under test it yielded 103–108% of the highest-yielding licensed cultivar each year. The hectolitre weight of RT124 was equal to Cougar and Puma and greater than Kodiak whereas 1000-kernel weight was equal to Kodiak. Heading and maturity were as early as Frontier (2–3 days earlier than Kodiak). Height of RT124 was equal to Puma and Frontier; however, its resistance to lodging was greater than that of Frontier, Puma, and Kodiak (but not equal to Cougar). Support of the Expert Committee on Grain Breeding for the licensing of RT124 will be requested in February 1980.

### Fertilizers

The data from fertilizer tests conducted on farmers fields throughout southwestern Saskatchewan since 1967 on stubble and fallow have been summarized. The results indicate that on the average there was little response to nitrogen for wheat grown on fallow, but a good response to phosphate. The phosphate response follows the law of diminishing returns with P at 20–30 kg/ha being the most profitable. On stubble there was an increase in grain yield of 8–9 kg/ha for each kilogram of N applied at N application rates of up to 45 kg/ha, but the increase in yield decreased to only 2.8 kg/ha for the next 15 kg of N applied per hectare. Soil nutrients at seeding time and rainfall were the factors that had the greatest effect on yield response to fertilizer on fallow,

whereas soil moisture at seeding time was the most important on stubble.

Only with N rates of 45 kg/ha or greater was there a significant increase in protein content of the grain. Phosphate reduced the protein. Few of the variables affected the protein content of wheat on fallow, whereas increased rainfall during the growing season tended to reduce the percent protein on stubble.

### Common wheat

NB320 (Tobari 66/Romany), a utility wheat line tested for 5 yr in the Non-Bread Wheat Co-op tests yields 35% more than Neepawa. NB320 has semidwarf stature, stiff straw, and matures about 7 days later than Neepawa. The quality of NB320 has been classified as being of medium protein content, medium hardness, and medium gluten strength. The kernels have a light red color.

NB112 (Ciano 's'/Sonora 64 – Klein Rendidor/8156), a utility wheat line tested for 4 yr in the Non-Bread Wheat Co-op, yields 10% more than Neepawa and matures 2 days earlier. NB112 is an awned semidwarf with stiff straw and white kernel color. The quality of NB112 has been classified as high flour yield, medium-high protein content, and strong gluten. This line was developed by L. E. Evans of the University of Manitoba and R. M. DePauw of the Research Branch, Agriculture Canada, using CIMMYT material.

Breeding for postseedling resistance to stem rust, either alone or in combination with seedling resistance, is more complex than breeding for seedling resistance alone and requires different methods.

### Prediction of field soil water content

Field soil water content could be successfully predicted using the Darcy flow water transport equations when the model parameters controlling flow were modified. A 3 yr experiment was conducted to monitor the field water contents. Hydraulic conductivity was calculated by the Millington-Quirk method, but direct use of the derived functions did not give exact fits to the observed field results. However, when reasonable adjustments (within field variability) were made to the conductivity and diffusivity function, the prediction was improved considerably. The

methodology of accounting for field variability and optimization of model parameters requires more research.

### **Variability in nitrate and chloride leaching**

In a 3 yr study conducted to examine how some of the soil and weather factors affected spatial variability of  $\text{NO}_3\text{-N}$  and Cl levels in field soils, it was found that uneven application of fertilizer accounted for 30–100% of the observed variation immediately after fertilization. However, as fertilizer granules dissolved, this variability decrease; then, differential rates of leaching of  $\text{NO}_3\text{-N}$  and Cl appeared to contribute significantly to variability, increasing the variation from about 40% to over 100%. Field and model results showed that differential leaching patterns could be attributed to two main factors: variability of physical properties that determine rates of water movement and storage, and point differences in spatial surface microrelief.

### **Measurement of salinity by an electromagnetic induction probe**

A noncontacting soil resistivity probe, based on electromagnetic induction, was used to measure soil salinity. Good correlations were obtained between the apparent bulk soil conductivity measured by the instrument and the electrical conductivity measured by the Wenner four-probe method. The electromagnetic induction technique provided less-detailed information on salinity changes with depth than did the other methods, but it was faster and could provide a continuous record of salinity changes along a transect.

### **Effect of dietary nutrient density on female turkeys**

Studies reported from this laboratory have demonstrated that toms from the heavy-tonnage commercial strains respond to higher nutrient-density levels.

An experiment using female poults of six commercially available strains raised to market age tested the effect of the nutrient density required at weekly intervals throughout the growing season. Six strains were used, three of which were high feed-intake strains and three medium-intake strains, for a total of 1200 birds.

The higher feed-intake strains had significantly faster growth rates at all nutrient-density levels than the medium-intake strains.

Two of the three high-intake strains responded to the increasing calorie:protein ratio at the higher nutrient-density levels.

The females were fed three constant nutrient-density levels (NDL-1 11.6, NDL-2 12.9, and NDL-3 14.1 kJ/g on metabolizable energy (ME) basis) and three increasing nutrient-density levels (NDL-4 from 11.8 to 12.9, NDL-5 from 13.1 to 14.1, and NDL-6 from 14.4 to 15.4 kJ/g on ME basis).

In strains A, B, and C (higher feed intake), growth rate was significantly faster at all nutrient-density levels than in strains D, E, and F (medium feed intake). Strains A and C responded to the increasing calorie:protein ratio at the higher nutrient-density levels.

Meat yield data indicated that breast meat and total skin percentage increased with chronological age. Strains A and C showed an increase in the yield of breast meat with an increase in nutrient density level. The percentage of thigh, drumstick, wing, and bone decreased with age.

The cooking loss data indicated a lower drip loss from females than from males. However, the skin fat and the gravy fat showed a higher percentage of fat in females. Nutrient-density level does not affect the percentage of fat in the skin and gravy sample as much as does chronological age. The percentage of fat in the breast and thigh meat tended to increase with chronological age and nutrient-density level. The percentage of nitrogen in the thigh tissue was significantly higher in females than in males. There was a highly significant increase in the gravy fat from the drip loss of the medium feed-intake strains over that of the higher feed-intake strains. The nutrient quality of the finished product (turkey meat) increased with the higher nutrient-density level.

### **Low glucosinolate rapeseed meal for turkeys**

Liveweights of small white turkeys fed 0, 75, 150, or 225 g/kg of Candle rapeseed meal (RSM) to 98 days of age were 5.76, 5.70, 5.60, and 5.46 kg. Addition of supplementary fat to the diets to compensate for the lower energy of RSM did not influence liveweight gains. Mortality was not increased by RSM. True ME values determined on the feedstuffs used accounted more satisfactorily for observed performance than published ME values.

## SOILS AND ENVIRONMENT

### Effect of nitrogen supply on the seed set of spring wheat and barley

Applications of  $\text{NO}_3\text{-N}$  increased seed set of wheat grown under hot, moist conditions. An attempt was made to determine whether this improvement in seed set was due to improvement in plant nutrition or to  $\text{NO}_3$  poisoning the soil  $E_h$  above that at which phytotoxic ethylene is produced. Two pot experiments were carried out in a controlled environment chamber at diurnal temperatures 27/12°C and slightly above optimum moisture.  $\text{NO}_3\text{-N}$  or  $\text{NH}_4\text{-N}$  with N-Serve (registered trade name) were applied to Manitou wheat, supplying N at rates of 45, 90, 135, and 180 kg/ha in the first experiment, and to Manitou wheat and Conquest barley, at rates of 23, 45, 90, 180, and 360 kg/ha in the second. N-Serve successfully maintained the nitrogen in the  $\text{NH}_4$  form throughout the experiment. In both experiments, the seed set of the primary and secondary florets of wheat was directly proportional to the  $\text{NO}_3\text{-N}$  rate. Wheat plants fed  $\text{NH}_4\text{-N}$  exhibited significantly higher seed set than  $\text{NO}_3\text{-N}$  fed plants at the low nitrogen rates. Seed set of lateral florets of barley was unaffected by rate, but the  $\text{NH}_4\text{-N}$  fed plants tended to produce slightly higher seed set. Ethylene was not detected in any of the soils. Since  $\text{NH}_4\text{-N}$  corrected the seed set problem even at low levels of nitrogen, it was concluded that poor nitrogen nutrition and not the production of soil ethylene was responsible for poor seed set of wheat.

### Reduction of fecal bacteria when irrigating with sewage effluent

When sewage effluent was pumped from a lagoon for spray irrigation the pumping process reduced the fecal coliforms (FC) by 66% and the fecal streptococci (FS) by 91%. It is of considerable sanitary significance that these fecal-indicator bacteria were found to be much more susceptible to the detrimental effects of pumping than the bacteria indigenous to unpolluted water and soil. Consequently, the bactericidal effects associated with the pumping of effluent were investigated in the laboratory by seeding sterilized effluent with fecal bacteria and repeatedly passing the liquid through a centrifugal impeller-type pump at 345 kPa. The pumping effect was cumulative, 49 and 90% of FC being killed

after two and four passages through the pump, respectively. FC were more susceptible than FS to injury by pressure shock. Very weak chlorination of the effluent increased the destruction of FC but not of FS during subsequent pumping. Within the range of experimental conditions used, the percentage of FC killed by pumping was not markedly affected by changes in temperature and pH of the effluent or by differences in the number and age of cells added. The results of these experiments provide a basis for further exploitation of the bactericidal effect of pumping as a management technique in waste-water irrigation.

### An improved manometer

A manometer that uses two fluids of different specific gravities has been developed. The manometer is similar to the conventional manometer except that it has an enlarged reservoir at the top of the tube. The lighter fluid floats on the heavier fluid so that the interface between the two fluids is in the manometer tube and the free surface of the lighter fluid is in the reservoir. The manometer is read at the interface. The differential manometer has a greater sensitivity than the conventional manometer and is useful for measuring small weight changes in a hydraulic lysimeter.

### Evaporation control on farm-sized reservoirs

Several methods of controlling evaporation from a free water surface were field tested. The use of monomolecular films was shown to achieve an 18% reduction in evaporation. Although further reduction in evaporation was achieved by combining this treatment with windbreaks and floating grids, the cost of water saved increased. Rafts were found to be a good alternative to monomolecular films. The most economical type of raft was made from lightweight concrete which conserved water at a cost competitive with monomolecular films.

### Nutrient runoff from fertilized and unfertilized fields in Western Canada

Nutrient transport in surface runoff from snow was measured from fertilized and unfertilized cropped and summerfallowed Wood Mountain loam fields in semiarid southwest Saskatchewan. The amount of nitrogen lost from unfertilized fields during spring runoff exceeded the limits purported to result in

algal growth; however, the loss was agronomically insignificant.

It was concluded that since the N and P concentrations in runoff from unfertilized fertile agricultural soils exceed Saskatchewan water quality criteria, these guidelines may be regarded as unattainable under our present system of cereal cropping in Western Canada.

#### Temperature, N fertilization, and moisture stress on wheat

The effects of temperature, fertilizer N, and moisture stress on the yield components, protein content, and moisture use efficiency of Manitou wheat (*Triticum aestivum* L.) were determined under simulated irrigation in a  $2 \times 3 \times 5$  factorial experiment. Grain yield was directly related to and mainly influenced by N. Yield was directly related to the number of spikes ( $r = 0.71^{**}$ ), and the number of seeds per spike ( $r = 0.65^{**}$ ), and inversely related to average seed weight ( $r = 0.41^{**}$ ). Seed weight was also inversely related to the number of spikes and number of seeds per spike. At maturity, the number of spikes was directly and mainly affected by N. The number of spikelets per spike, seed set of primary and secondary florets, and seed weight were inversely related to, and mainly a function of, temperature. At high temperature and low  $\text{NO}_3\text{-N}$ , low moisture stress was detrimental to several yield components where these conditions existed during a period critical to the development of the component. These poor responses were alleviated by high moisture stress or high rate of  $\text{NO}_3\text{-N}$  fertilizer or both. Grain protein was mainly influenced by temperature to which it was directly related. Protein was increased by N at day/night temperatures of 22/12°C, but was unaffected by N at 27/12°C; it was also increased by high moisture stress applied between last leaf visible and anthesis. Grain protein was inversely related to grain yield at any given level of N. Covariance was used to isolate the true effect (i.e. corrected for yield effects) of the treatment variables on protein. In this experiment, N influenced protein only via its effect on grain yield. Moisture-use efficiency for grain production was improved by all factors that increased grain yield (e.g. increased N, low temperature, or high moisture stress between tillering and last leaf visible). Efficiency was deleteriously affected by moisture stress between last leaf visible and anthesis.

#### The effect of fertilizer N and soil moisture on wheat

The influence of rate of fertilizer N and soil moisture on N uptake by spring wheat, N mineralization, *A*-values, and N recovery was determined in small lysimeters on stubble land by means of  $^{15}\text{N}$ -labeled  $\text{KNO}_3$ . Net mineralization was enhanced by frequent irrigations but depressed by cropping. In contrast to most growth-chamber results, N uptake was not linearly but logarithmically related to rate of application; uptake from fertilizer was positively related to rate, but only up to a point, beyond which it leveled off; uptake from native soil N was generally negatively related to rate; *A*-values were not constant but negatively related to rate except at the highest rates (N at 123–164 kg/ha) when they were positively related especially under dry conditions. These differences in results were credited to the fact that the pot system does not adequately simulate the field situation. On dryland an average of 68, 20, and 12% of the plant N was located in the grain, straw, and roots, respectively; under irrigation the corresponding values were 75, 16, and 9%. On dryland the average recovery of fertilizer N from soil was 34.6%, grain 37.3%, straw 12.2%, roots 2.6%, error 6.0%, and unaccounted 7%; under irrigation it was 15.4, 58.3, 13.0, 3.5, 6.0, and 4.0%, respectively. On dryland about 28% of the fertilizer N was left in the soil at rates supplying N at up to 82 kg/ha, whereas 57% was left at 164 kg/ha; under irrigation the corresponding values were 15 and 21%, respectively. On dryland >70% of the residual N was located in the 0–30 cm soil segment at fertilizer N rates <82 kg/ha; at higher rates, >50% was in the 30–60 cm segment. Only with fertilizer N at 164 kg/ha was there appreciable residual N in the 30–60 cm segment under irrigation. There was negligible fertilizer N below 60 cm in all treatments.

## FORAGE PRODUCTION AND UTILIZATION

### Spring and summer pastures

Fall rye (*Secale cereale* L.) as a spring and early summer supplemental pasture was compared to the seeded perennial grass pastures Russian wild ryegrass (*Elymus junceus* Fisch.) or Altai wild ryegrass (*Elymus angustus* L.). Over a 4 yr period the fall rye

pastures provided 7 wk of grazing each year from about 10 May to late June. The Russian wild ryegrass pastures were grazed for 12 wk from early May to early August, whereas Altai supported grazing for 15 wk from early May to late August.

As a consequence of different daily rates of gain and different stocking rates between the three crops, the productivity per land unit varied as follows: fall rye produced an average of 134 kg of seasonal liveweight beef gain per hectare, Russian wild ryegrass 191 kg/ha, and Altai wild ryegrass 286 kg/ha.

Typical native grass rangeland in this vicinity produces from 15 to 20 kg/ha per season.

### Time of irrigating alfalfa

Various start and stop dates in scheduling irrigation had no effect on winter injury to alfalfa stands located on well-drained soil over a 6 yr period.

Irrigating with cold water (5°C) very early in the spring (1 May) delayed spring growth sufficiently to result in first-cut yields that were 13% lower than those where the first irrigation was delayed for 2 wk.

### Ruminant nutrition

Treatment of wheat straw with high-pressure steam increased intake of digestible energy more than did  $\text{NH}_3$  treatment, but both treatments increased nutritive value substantially over that of untreated straw. Digestibility of cell-wall constituents of crested wheatgrass and Russian wild ryegrass did not markedly change with advancing maturity, but the proportions of cell-wall constituents to cellular contents changed markedly. Decreased digestibilities of energy were associated with advancing maturity of crested wheatgrass, Russian wild ryegrass, and Altai wild ryegrass, and in the case of crested wheatgrass, so was a pronounced decrease in voluntary intake. Supplementation of these species with N and P increased digestibility of energy on mature forage by up to 20% and increased voluntary intake by as much as 30%. Fertilizer application increased percent N and in vitro organic matter digestibility (OMD) for these species, with the effect decreasing to zero at maturity. In vitro rumen gas production studies with Russian wild ryegrass, Altai wild ryegrass, and crested wheatgrass showed that most rapid gas production was associated with lowered nutritive

value and that supplementation of these species with N and P may increase nutritive value through reduction of energy or N losses or both as gas. Studies on transfer of methionine across the ovine placenta, using cannulated ewe-fetus preparations, were completed, and kinetic equations describing the transport processes were developed. Studies were initiated on the transport of vitamin D and its metabolites in relation to Ca and P in the cannulated ewe-fetal preparation. Blood urea nitrogen appeared to be a useful indicator of dietary protein adequacy in the ruminant, with metabolic indicators of energy sufficiency less useful.

### Seeding rates and row spacings in grasses and alfalfa

In 1974 Russian wild ryegrass, crested wheatgrass, and alfalfa were seeded on dryland either alone or in alternate grass-alfalfa rows. Three row spacings (30, 60, 90 cm) and at six seeding rates of 17, 35, 50, 67, 83, and 100 seeds per metre row were used to determine the optimum seeding rate at each row spacing. Greater yields resulted from higher seeding rates for all crops only in the first harvest year. By the second harvest year, seeding rate did not affect the yield of pure stands of each grass. In the third and subsequent harvest years, seeding rate had little or no effect upon dry matter yield of any of the crops. Seeding rates did not interact with row spacings in any year. Initially, the narrower row spacings produced the highest yields, but by the third harvest year the wider spaced rows were yielding more than the narrower spaced rows. The row-spacing effect continued in subsequent harvest years.

### Yield aspects of grasses

Twenty grass populations were evaluated for dry matter yield, N content, P content, organic matter content, organic matter digestibility, and winterhardiness. Of these populations, *Agropyron intermedium* was most suitable for a hay crop on a well-drained irrigated soil. *Agropyron trichophorum*, *Bromus inermis*, and *Phalaris arundinacea* were lower-yielding alternatives that had a satisfactory N content and good digestibility. *Elymus angustus* shows promise as an irrigated hay crop and should be evaluated further. The usefulness of the following populations was limited by one or more of these factors—low yield (Y), low N content



(*N*), low digestibility (*D*), and lack of winter-hardiness (*W*): *Dactylis glomerata* 'Kay' (*Y*, *N*, *D*), *Dactylis glomerata* 'Chinook' (*Y*, *N*, *W*), *Elymus sibiricus* (*Y*), *Festuca arundinacea* 'Kenmont' (*Y*, *N*, *W*), *Festuca elatior* 'Trader' (*Y*, *N*), *Phleum pratense* (*Y*, *N*, *D*), *Poa ampla* 'Sherman' (*N*, *D*), *Poa bulbosa* cv. P4874 (*Y*, *N*, *D*), and *Poa pratensis* (*Y*, *N*, *D*).

In a study of distribution patterns in grassland, density determinations were made in 154 stands, using stratified random samples of quadrats, and distance measurements obtained with the point centered quarter method. The results showed that individuals in the population, regardless of species, were randomly dispersed if the substrates were reasonably homogeneous, and disturbances were absent.

Heterogeneity of the substrate, disturbances, and what may be termed successional development commonly caused deviations from randomness resulting in more or less pronounced aggregation. The form of aggregation depended on the mode of vegetative or sexual reproduction of species.

On homogeneous substrates, species occurring with high densities often were dispersed in a regular pattern, usually as regularly dispersed aggregates. The species involved

were mostly bunchgrasses or herbs with branching caudices. The cause of 'regular aggregation' appeared to be breaking up of bunches or caudices into several individuals, due to aging of the plants.

#### A genetic study on Altai wild ryegrass

Progenies from a six-genotype diallel cross in Altai wild ryegrass (*Elymus angustus* Trin.) were studied to assess the pattern of genetic control for  $F_1$  seed weight and a number of seedling and adult plant characters. Variation in  $F_1$  seed weight was largely determined by the maternal parent, but some control by the pollen parent was apparent. Gene action was additive, but some nonadditive genetic effects were also present. All of the seedling characters, days to emerge, rate of leaf appearance, rate of tiller appearance, and seedling dry matter yield showed additive control which is amenable to direct selection. Diallel analyses indicated that the adult plant characters, days to inflorescence appearance, digestible organic matter, total dry matter yield, and total seed yield were controlled by strong additive control which is amenable to direct selection. The seedling characters, rate of leaf appearance, rate of tiller appearance, and seedling dry matter yield were interrelated, but only rate of tiller appearance was associated with adult plant yield.

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*Agriculture Research Council of Alberta*

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Cereal agronomy

## INTRODUCTION

The Northern Research Group, which comprises the Research Station at Beaverlodge and the associated experimental farm at Fort Vermilion, Alta., is largely responsible for research on agricultural problems of northwestern Canada. This report presents highlights of research for 1979.

Considerable progress was made in understanding the causes of winter injury in alfalfa fields and how improved management techniques can avoid these unnecessary losses. Weed control practices were further refined for commercial stands of several perennial grasses grown for seed with emphasis on control of dandelions and wild oats. In plant pathology major research effort was devoted to the various diseases of rapeseed and the stem eyespot disease of creeping red fescue. Seed production research with native grasses for ecological repair and leafcutting bees for pollinating alfalfa contributed to Canada's forage seed industry. Soils research enhanced understanding of the role of lime and chemical fertilizers as soil amendments.

Detailed information can be obtained from the publications listed in this report. Correspondence to individual research scientists should be addressed: Research Station, Research Branch, Agriculture Canada, Box 29, Beaverlodge, Alta. T0H 0C0; and Experimental Farm, Research Branch, Agriculture Canada, Fort Vermilion, Alta. T0H 1N0.

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## APICULTURE

### Behavior

*Queen replacement.* To replace the colony population with the offspring of the new queen, the new queen should be introduced prior to the end of August. Various replacement methods currently exist. Using 240 colonies, 24% of the queens were replaced by queen cell introduction. Supersedure queens were found in 27% of the colonies, and the original queen was found in 47%.

## ENVIRONMENT

### Meteorology

*Role of meteorological factors in promoting leafcutting bee activity.* Global solar radiation played the prominent role in maintaining bee pollination activity. Air temperature provided a threshold barrier which limited flight in the morning. Atmospheric vapor pressure proved to be of no consequence.

### Plant survival

*Factors associated with injury to alfalfa.* The winter of 1977-1978 was severe for many perennial legumes in northern Alberta and

British Columbia. The winter was characterized by killing frost on 1 September 1977 and  $-28^{\circ}\text{C}$  and  $-43^{\circ}\text{C}$  air temperatures in late November and early December, respectively, prior to any appreciable ground snow cover. This caused soil temperatures at 5 cm to drop  $-19^{\circ}\text{C}$  at Beaverlodge. Cold hardiness measurements ( $LT_{40}$ ), etiolated regrowth weight measurements of root food reserves, and visual percent stand estimates were determined on various cultivars of *Medicago sativa*, *M. media*, and *M. falcata* prior to, during, and/or following the 1977-1978 winter. Fall cutting management studies indicated that alfalfa harvested during August or early September suffered severe injury. First-cut yields in June 1978 were up to 50% lower than the yields from control plots. *M. sativa*, *M. media*, and *M. falcata* cultivars left for seed showed little evidence of winter injury. The results suggest that low fall food reserves which resulted from harvesting during August or early September and low soil temperatures in December and January were two primary factors associated with winter injury. *M. sativa* stands cut twice in 1977 were more severely injured than stands of *M. media* or *M. falcata*. Three-year-old stands of *M. media* were more severely injured than two-year-old stands.

*Changes in cold hardiness of alfalfa.* Plants of *Medicago falcata* cv. Anik were sampled to assess their relative cold hardiness during the fall, winter, and spring periods from 1974–1975 to 1978–1979. Precipitation and soil-temperature patterns and cold-hardiness profiles varied considerably from year to year. Environmental conditions in the fall appeared to exert the greatest influence on the cold-hardiness profile and the maximum cold-hardiness level in midwinter. In general, plants started to harden in mid-September. However, hardening was delayed in the fall of 1976. This delay was associated with the early development of crown buds and the accompanying flush of growth during August and September. During two fall-hardening periods, water-saturated soil conditions were associated with a dehardening phase in October. Conditions favoring delayed fall hardening and complete dehardening in the late fall were also associated with a lower level of hardiness in midwinter. The maximum hardiness level, and the month during which it occurred, fluctuated considerably each year. Plants began dehardening as soil temperatures increased in late winter and early spring during 3 yr of the 5 yr period but, in the remaining 2 yr, plants began to deharden prior to an increase in soil temperature.

### Weed control

*Effect of grass species and row spacing on dandelion establishment and growth.* The size of dandelions growing in intermediate wheatgrass, crested wheatgrass, a northern biotype of brome grass, a southern biotype of brome grass, meadow fescue, creeping red fescue, and timothy was effectively reduced by decreasing the row spacing of each grass from 100 cm to 20 cm. Russian wild ryegrass had only a minor effect on dandelion size regardless of the row spacing at which it was planted. Within any given row spacing between 20 and 100 cm, dandelion density was not affected by grass species. However, as the row spacing decreased from 20 cm the average density of dandelions growing in the seven grass species also decreased.

*Wild oat control in seedling forage grasses.* Field and greenhouse studies have been conducted on the use of diclofop methyl (0.84–2.24 kg/ha), barban (0.35–0.70 kg/ha), difenzoquat (0.83–1.12 kg/ha), and flamprop methyl (0.42–1.68 kg/ha) to control wild oats in creeping red fescue, crested wheatgrass,

meadow fescue, brome grass, intermediate wheatgrass, timothy, reed canarygrass, Kentucky bluegrass, and Russian wild ryegrass.

Diclofop methyl at all rates and flamprop methyl at 0.84 kg/ha gave satisfactory wild oat control during each of the 4 yr the study was conducted. Barban gave good wild oat control in 2 yr out of 3 yr in the field. Increasing the rate from 0.35 to 0.70 kg/ha did not produce a major improvement in wild oat control. Control of the weed from applications of difenzoquat ranged between poor and fair.

Creeping red fescue, crested wheatgrass, intermediate wheatgrass, and Russian wild ryegrass were generally tolerant to diclofop methyl. Brome grass varied from year to year in its tolerance of diclofop methyl. Injury occurred in the greenhouse and in one of the years in the field. All other grasses were severely injured by diclofop methyl. All grasses were tolerant of difenzoquat, and all grasses except reed canarygrass and Kentucky bluegrass were tolerant of barban and flamprop methyl.

### Plant pathology

*Brown girdling root rot of rapeseed.* Greenhouse pot trials were run to test the effectiveness of narrow-spectrum fungicides in controlling brown girdling root rot. Fungicides specific for Phycomycetes, Ascomycetes, or Basidiomycetes each caused some root rot reduction without producing adequate control, indicating participation by fungi from each of these three major fungus groups in the root rot complex. The nematocide used did not control root rot and was phytotoxic. Soil from the root rot nursery used in these pot trials did not contain phytopathogenic nematodes. It appears therefore that nematodes neither cause this root rot nor provide wound entry sites for associated fungi.

Over 3000 plants were rated for root rot, sterility, staghead, and grey stem. No relationship between seeding date and severity of root rot was found. Significant levels of root rot were found on Argentine rape for the first time, although the disease was still appreciably less severe than on Polish rape.

*Damping-off of rapeseed.* Isolation studies confirmed that there is a wide spectrum of putative soil-borne pathogens in this complex, and comparison with limited studies elsewhere suggests that there is a higher percentage than elsewhere of soils dominated by



*Pythium* spp. for which no seed treatment is available, whereas available seed treatments are fairly effective in reducing damping-off due to *Rhizoctonia* and *Fusarium* spp., the other principal agents.

*Stem eyespot disease of creeping red fescue.* For the first time in applying fungicides in the field, complete control of all disease symptoms was obtained even though infection in the untreated checks was moderately heavy. Six fungicides were applied at six dates during the season from one to six times per plot. Complete control of symptoms was obtained with biloxazol and fenarimol at two or more applications per plot, and benomyl gave partial control. Most treatments also caused phytotoxicity to seed heads although none was evident on foliage. However, all dosage rates were at or above manufacturers' suggested rates.

Etiological studies to resolve two conflicting theories as to the mode and timing of most infections failed to produce any evidence for early season mycelial invasion from debris, but strongly supported infection arising from spores later in the season in association with humid weather, although direct evidence is still lacking. Typical lesions were produced by inoculating clean plants with spore suspensions in the greenhouse, but only under continuous misting. This is hardly representative of field conditions, so considerable refinement in technique is required. Confirmation that overwintering of infected stems is required for sporulation to occur was obtained, and studies on inducing sporulation of both naturally infected stems and pure cultures by artificial cold treatments are under way.

## FORAGE CROPS

### Seed production

*Native grasses as commercial seed crops.* The potential seed production capacity of 15 native grasses collected throughout northwestern Canada was assessed. All species proved to have a strong propensity to produce seed and showed no response to aftermath removal. As with our cultivated grasses, soil nitrogen is a prime requirement for seed head formation. None appeared to be particularly sensitive to the commercial herbicides normally used for the control of broad-leaved weeds in established grass stands.

*Breeding and management of Megachile rotundata for alfalfa seed production in northwestern Canada (lat. 55–58°N).* A northern strain of leafcutting bees, *Megachile rotundata*, that commences pollination of alfalfa at 0.5–1.7°C lower temperature and 15–45 min earlier than do bees from southern Alberta (lat. 49–51°N), has been developed through natural selection in the harsh environment of northwestern Canada (lat. 55–58°N) and by improved management techniques of using shelters made from polyethylene or other similar transparent or translucent material. The reproduction ratio of northern bees in 1976 and 1977, 2 yr with below-normal July temperatures, were 3 and 1.3 times, respectively, above southern Alberta bees. Four or more generations in the north are required to adapt southern Alberta bees to the northern Alberta environment.

An inverse relationship between concentration of bees per hectare of alfalfa and reproduction of cells was demonstrated with the reproduction ratio ranging from 2.3 to 1.3 at 15 000 to 80 000 bees per hectare, respectively.

Seed yields declined with increased length of flight. At 40 000 bees per hectare there was a reduction of yield from 712 kg/ha at 2–5 m from the cage, to 666 kg/ha at 18 m, and to 440 kg/ha at 35 m with an average yield of 480 kg/ha. Higher bee populations are required for maximum potential. Seed blast (insect damage) was low in treated fields but much higher in unsprayed areas, indicating need for insect control.

## SOILS

### Soil fertility

*Effects of soil acidity and liming on mineralization of soil nitrogen.* Forty acid-surface soils of pH 4.0–5.6 were incubated with and without lime, and the amounts of N that were mineralized or nitrified were compared with several soil-acidity characteristics. In addition, three field experiments were used to find the effect of liming on N mineralization. There was no relation between the amounts of mineral N released per unit of organic N in 120 days of incubation and soil pH, base saturation, or soluble Fe, Al, or Mn. Despite this, liming the soils to about pH 6.7 approximately doubled the amounts of N mineralized during incubation. In the field experiments, lime increased uptake of soil N

by 15–42 kg/ha in the 1st yr but only 7–10 kg/ha in the 3rd yr. Thus these laboratory and field experiments indicate that soil acidity does not restrict mineralization of organic N and although liming increases mineralization of N, it is generally a temporary effect. Nitrification in the 40 incubated soils occurred much more rapidly in cultivated soils than in virgin soils. For both the virgin and cultivated soils, nitrification decreased with decreasing soil pH. However, nitrification was not related to base saturation or soluble Fe, Al, or Mn. Liming established good nitrification in most of the soils and this effect did not diminish with time.

*Correction of severe manganese deficiency in wheat with chemical fertilizers.* Manganese, N, and P fertilizers were applied to

wheat in field experiments on a soil so deficient in Mn that it caused the wheat to die before heading. Yields of wheat were increased linearly by soil-banded Mn to 44.8 kg/ha, giving a yield of 3.03 t/ha. Yields were increased to a lesser extent by foliar-applied Mn and least by soil-broadcast Mn. Soil N and P appeared to be adequate, yet ammonium sulfate at 56 kg/ha when applied alone caused a yield of 1.69 t/ha and ammonium sulfate nitrate gave a yield of 0.98 t/ha, the increases being primarily due to the release of Mn to the plants. Calcium nitrate and triple superphosphate were much less effective in releasing Mn.

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### Research

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## INTRODUCTION

This report summarizes some of the results of research conducted at the Lacombe Research Station during 1979.

A new set of adjustment factors were developed for the ROP beef herd test program and the usefulness of ultrasonic measurements of fat in the live animal as a predictor of carcass composition was compared with linear measurements on the carcass after slaughter. Evaluations of foreign breeds were continued with comparisons of the performance among the progeny sired by bulls of several breeds. Factors affecting the storage life of meat under simulated retail conditions were studied. The oat cultivar Cascade was licensed, the fourth oat cultivar developed at Lacombe using the single-seed-descent method of plant breeding. Interactions between various herbicides were investigated to develop more economical methods of controlling a wide spectrum of weeds.

Further information on any of these research activities, reprints of publications listed in this report, and copies of previous reports may be obtained from: Research Station, Research Branch, Agriculture Canada, Lacombe, Alta. T0C 1S0.

D. K. McBeath  
Acting Director

## ANIMAL SCIENCE

### Beef

*Additive age-of-dam adjustment factors for weaning weight of beef cattle.* Based on a study of 373 351 weaning weight records from the Canadian beef cattle Record of Performance herd test program, it was concluded that, although the statistical interaction between age of dam and breed of sire was significant ( $P < 0.05$ ), it was small enough to be ignored for practical purposes. This justifies the use of a single set of age-of-dam adjustment factors across all breeds of sire. A set of additive factors to adjust calf weaning weight for age of dam (2, 3, 4, and 5 yr or more) within sex of calf (male or female) was presented for each of the following breed-of-dam classes: Angus, Charolais, Hereford, Shorthorn, British breed crosses, half Charolais-half British, half Simmental-half British, and others.

*Live ultrasonic measurement of subcutaneous fat for prediction of beef carcass composition.* A study of 356 steers and heifers of various breed crosses revealed that ultrasonic readings taken 15 cm off the midline (over the 11th rib) were slightly more highly correlated with carcass composition traits than measurements taken 5 or 10 cm off the midline, and that the incorporation of additional fat depth measurements in the 11th rib area did not materially improve the relationship between

fat depth data and carcass composition traits. Fat measurements taken with a ruler were more highly correlated than ultrasonic measurements with carcass percent fat ( $r = 0.59$  versus 0.34), with percent lean ( $r = -0.45$  versus  $-0.33$ ), and with kilograms of fat at a constant carcass weight ( $r = 0.56$  versus 0.35). Ruler measurements and ultrasonic measurements for fat depth were equally correlated to kilograms of lean at constant carcass weight ( $r = -0.34$  versus  $-0.33$ ). Breed and sex accounted for 23% of the variation in carcass fat percent and 21% for weight of fat at a constant carcass weight. Ultrasonic fat measurements accounted for an additional 12% and 10% of the variation. Breed and sex accounted for 12% of the variation in percent lean and 51% of the variation in kilograms lean at constant carcass weight. Ultrasonic fat depth measurements accounted for an additional 9% and 3% of the variation.

*A comparison of Simmental with Limousin steers for feedlot and carcass traits.* A comparison between 18 Simmental and 30 Limousin steers revealed that the Simmentals exceeded the Limousins in weight at the beginning of the postweaning gain test ( $37.6 \pm 12.3$  kg), daily gain ( $0.12 \pm 0.04$  kg), percent hide of liveweight at slaughter ( $1.58 \pm 0.27\%$ ), percent dissected intermuscular fat ( $1.2 \pm 0.3\%$ ), and percent bone ( $4.3 \pm 0.5\%$ ). Limousins exceeded Simmentals in

dressing percent ( $5.2 \pm 0.4\%$ ) and percent dissected lean ( $6.8 \pm 0.8\%$ ). The breeds did not differ significantly in age on test, feed consumption per unit of gain, slaughter age, hot carcass weight, average rib fat depth, marbling score, or shear force of cooked samples (tenderness). Thus, while the Simmental steers gained more rapidly, the Limousin steers produced more lean meat of equal quality per unit of liveweight gain.

*Performance of progeny produced by Charolais, Simmental, Limousin, and Chianina bulls mated to exotic first-cross dams.* Summaries of results from cooperative foreign cattle breed evaluation projects involving the Brandon, Lacombe, and Lethbridge research stations revealed that Charolais-sired calves tended to be more difficult calving, heavier, and faster growing; Limousin-sired calves tended to be easier calving, lighter, and slower growing after weaning; while calves sired by Chianina or Simmental tended to be intermediate but closer to Charolais in these performance traits.

Dissection of the round and long loin established that Limousin-sired carcasses had a lower proportion of bone and a higher proportion of lean tissue than carcasses from the other breeds of sire. Chianina-sired carcasses had the highest proportion of bone but also a greater proportion of high-priced cuts, and they ranked second to the Limousin-sired carcasses in dressing percent and carcass yield of lean meat. Simmental-sired and Charolais-sired carcasses were similar in many respects but Simmental-sired carcasses had heavier hides, lower dressing percent, and a slightly lower carcass yield of lean.

## Swine

*Joint damage in pigs reared in confinement.* Foreleg joints of boars, barrows, and gilts slaughtered at weights of 82–116 kg were scored for degree of cartilage damage. The incidence of completely normal cartilage was less than 20% and moderate to severe damage was very common. The incidence of joint damage could not be related to sex, carcass traits, or visual scores of physical soundness. The degree of damage was related to the time spent under confinement feeding conditions and was greater in individually fed than in group-fed pigs. Cartilage repair was observed in pigs held on pasture following confinement.

*A genetic study of cryptorchidism and scrotal hernia in pigs.* Genetic parameters have been estimated for cryptorchidism and scrotal hernia. Liability of cryptorchidism identified at birth had a heritability of 0.5 but the heritability of cryptorchidism that developed after birth was almost zero. Scrotal hernia had a heritability of 0.65 and 0.86 in two herds studied and its genetic correlation with cryptorchidism was calculated to be 0.20. Methods were developed to calculate selection differentials for family selection and the expected changes resulting from full-sib and half-sib family selection were calculated.

*Hog marketing strategies.* In a study of 286 pigs marketed in six weight classes it was established that, under 1979 market conditions, pigs produced in a continuous production system should be marketed at 100–110 kg live weight but batch producers should market their pigs as heavy as 120 kg. Feed consumption and fatness increased linearly with both market weight and days on feed throughout this weight range. Barrows were faster growing and fatter than gilts but the differences did not justify differential management or pricing. The recommendations of this study apply to the pig feeding industry but not necessarily to the total pork industry.

## MEATS

### Preservation and shelf life

The influence of retail sanitation on the bacterial load and subsequent shelf life of rib steaks was investigated under laboratory-simulated retail processing conditions. Steaks were fabricated employing extensively sanitized processing equipment ( $<10$  bacteria per square centimetre of surface) or with highly contaminated equipment where bacterial counts approached  $10^6/\text{cm}^2$ . No significant differences were observed in the initial bacterial load, in the bacterial growth rate, or in the organoleptic deterioration of steaks processed under these extremes of retail sanitation. These results were confirmed with ground beef fabricated under similar extremes of grinding sanitation. Although the bacterial load on steaks could not be related to the degree of retail processing sanitation, it was significantly correlated with the level of surface contamination on wholesale ribs. In



addition, the extent of steak surface discoloration and overall retail appearance were significantly correlated to the bacterial load.

Laboratory-simulated retail conditions were employed to examine the effects of retail display temperature upon the growth of bacteria and the retail case-life of rib-eye steaks. The temperature of continuously displayed steaks ranged from 7.5 to 14.2°C and under these conditions an average case-life of 2.4 days was determined. However, when steaks were limited in their time of retail display by overnight refrigeration in a walk-in cooler (1°C), steak temperature was reduced to 1°C and retail case-life substantially extended to 4.9 days. Increased retail case-life resulted from a reduction in bacterial growth which was related to the rate of deterioration of steak retail appearance. These findings provide an alternative to the continuous retail display of beef which, if applied, could greatly improve beef case-life and reduce spoilage losses.

#### **PSE (watery) pork**

A large-scale survey of Canadian pork carcasses at three major packing plants and encompassing carcasses of a wide range in carcass fatness and weight indicated that the frequency of moderately to severely watery pork (PSE) ranged from 10 per 1000 carcasses to 50 per 1000 carcasses (plant nos. 3 and 2, respectively). Sex, fatness, and weight of carcass were not significantly related to post-mortem glycolytic rates (pH decline) or to ultimate PSE scores. The importance of ante- and post-mortem environment on development of PSE musculature is emphasized. Methods of early detection of potentially PSE muscle, such as pH and temperature, were found to be imprecise.

## **PLANT BREEDING AND PATHOLOGY**

#### **Oat breeding**

*Cascade oats.* Cascade, a new high-yielding oat cultivar developed at Lacombe, was licensed in 1979 for sale in Canada. In 4 yr of testing in the Gray and Black soil zones it outyielded Grizzly by 9.4%, Harmon by 18.3%, and Random by 11.7%. Cascade matures 3–4 days earlier than Grizzly, at a similar time to Harmon, and 1–2 days later than Random. It has good lodging resistance

and is similar to Grizzly in plant height and kernel characteristics. Cascade is susceptible to stem and crown rust and is therefore not recommended for production in the eastern prairies of Canada. Grizzly, Harmon, and Random are the most widely grown oat cultivars in Alberta. Because of its superior performance relative to these cultivars, Cascade is expected to have a marked impact on oat production in the Gray and Black soil zones. Cascade is the fourth cultivar developed at Lacombe using the single-seed-descent method.

#### **Cereal diseases**

*Causal agents of barley root rot.* It has been shown that the prevalence of the fungi causing barley root rot is dependent both on the time of the growing season and on geographic location. *Helminthosporium sativum* was six times as prevalent as *Fusarium* spp. in the early part of the season and three times as prevalent in the later part of the season at Lacombe. This was true when barley was grown under several conditions in a rotation study.

*H. sativum* was found to be the major cause of barley root rot on the southern prairies of Alberta and Saskatchewan while *Fusarium* spp. were the major causes of the disease in northern Alberta (Peace River block).

#### **Forage diseases**

*Yellow leaf blotch of alfalfa.* Twenty-five alfalfa cultivars were screened for resistance to yellow leaf blotch caused by *Leptotrochila medicaginis* (Fckl.) Schuepp. Highly significant differences were found, and the data indicated that resistance is of complex inheritance and may be difficult to obtain by selection.

## **CROP MANAGEMENT AND SOILS**

#### **Weed research**

*Interaction between difenzoquat and other herbicides for wild oat and broad-leaved weed control in barley.* The interaction between barban, a herbicide active at the two-leaf stage of wild oats, and difenzoquat, a herbicide active at the three- to five-leaf stage of wild oats, was additive upon application at the two- or four-leaf stage of wild oats. Wild oat control with a mixture of barban and difenzoquat at 0.14 + 0.42 kg/ha applied at

the two- or four-leaf stage was as effective as the recommended field rate of barban alone (0.28 kg/ha) at the two-leaf or difenzoquat alone (0.84 kg/ha) at the four-leaf stage. Barley yield increases with the mixture were comparable to those obtained with the full rates of the herbicides used alone at their correct leaf stages. This mixture offers the farmer excellent wild oat control, an extended latitude for spray application (two- to four-leaf), excellent barley yield increases, and the possibility of reduced operating costs. The herbicidal activity of difenzoquat or a barban plus difenzoquat mixture was reduced on addition of amine formulations but not ester formulations of broad-leaved weed herbicides. MCPA ester and bromoxynil plus MCPA were the most compatible broad-leaved weed herbicides when mixed with difenzoquat. Difenzoquat or difenzoquat plus barban significantly stimulated the herbicidal activity of various broad-leaved weed herbicides on Tartary buckwheat. A mixture of barban, difenzoquat, and bromoxynil-MCPA or MCPA ester provided effective wild oat and Tartary buckwheat control. The latter mixtures enable a farmer to eliminate one spray operation. The interaction between difenzoquat and dichlofop methyl was additive. Wild oat control with the mixtures was good and barley yield was increased over that obtained with a recommended field rate of dichlofop methyl.

*Interactions between barban and benzoylprop ethyl, flamprop methyl, or flamprop isopropyl applied at two growth stages for wild oat control in cereals.* Reduced rates of barban were combined with reduced rates of benzoylprop ethyl and flamprop methyl in wheat or flamprop isopropyl in barley, and the effects of the combinations on wild oat control and crop yield were assessed. In greenhouse experiments, the interaction in all three combinations was synergistic following application at the two- or four-leaf stage of wild oats. Under field conditions, all three combinations applied at reduced rates of the herbicides at the two- or four-leaf stage of wild oats were as effective for wild oat control and crop yield response as the recommended field rates of barban (0.28 kg/ha) applied at the two-leaf stage or benzoylprop ethyl (1.4 kg/ha), flamprop methyl (0.56 kg/ha), or flamprop isopropyl (1.4 kg/ha) applied at the four-leaf stage of wild oats.

*Interaction between benzoylprop ethyl, flamprop methyl, or flamprop isopropyl and herbicides used for broad-leaved weed control.* A marked antagonism of wild oat control was found when 2,4-D, dicamba, 2,4-D-dicamba-mecoprop, or bromoxynil were added to benzoylprop ethyl, flamprop methyl, or flamprop isopropyl. Because of the much poorer control of wild oats by these mixtures, obtaining broad-spectrum weed control with them in one spray operation would not be possible. The wild oat herbicides did not, however, affect the activity of these broad-leaved weed herbicides on Tartary buckwheat. In eight out of nine mixtures tested there was no significant antagonism (in field conditions) when MCPA or bromoxynil-MCPA was added to the wild oat herbicides, though a trend toward antagonism was evident. There were significant antagonistic effects, however, in six out of nine such mixtures in glasshouse experiments. The differences observed between glasshouse and field results may be attributed to the fact that under field conditions the presence of a competing crop may assist the mixtures in controlling wild oats and thereby mask the antagonism. Thus, under farm use conditions benzoylprop ethyl, flamprop methyl, or flamprop isopropyl may be mixed with MCPA amine or ester or with bromoxynil-MCPA to obtain broad-spectrum weed control from one spray operation, though slightly poorer wild oat control may be expected with these mixtures.

*Influence of simulated rainfall on the efficacy of postemergence wild oat herbicides.* Reduced effectiveness of postemergence wild oat herbicides has been observed under field conditions if rain fell during or shortly after application. In order to investigate the loss further, tests were conducted in the greenhouse to study the effects of a simulated short cloudburst at various times up to 48 h after spraying on the effectiveness of wild oat herbicides. The herbicides were first applied and the leaves of wild oats were subsequently washed by immersion of the plants in water. The results indicated that the herbicide treatments fell into two main categories. One group (barban, benzoylprop ethyl, barban plus benzoylprop ethyl, and flamprop methyl) showed no significant loss of efficacy with the simulated cloudburst 0.5 h after spraying.

The other group (dichlofop methyl, difenzoquat, and barban plus difenzoquat) required a dry period of 4–12 h after treatment to maintain maximum efficiency. Although a more thorough study of the effects of rain intensity and duration on the efficacy of wild oat herbicides is warranted, these results provide an indication to a farmer of the likely effectiveness of his wild oat spray program in the event of a heavy shower shortly after the spray operation.

*Influence of various herbicides for broad-leaved weeds and Tween 20 on control of wheat, barley, oats, and rape with a low rate of glyphosate.* Glyphosate at 0.21 kg/ha applied at the four-leaf stage consistently provided excellent control of volunteer wheat, barley, oats, and rape. Tank mixtures of glyphosate at 0.21 kg/ha with 2,4-D, dicamba, MCPA, bromoxynil–MCPA, or bromoxynil resulted in an initial reduction (antagonism) of glyphosate activity on the grass species at 5 days after treatment. At 34 days after treatment, the early differences had disappeared and killing of the grasses was virtually complete with all treatments containing glyphosate. The early reduction in control of the annual grasses with these mixtures was overcome in most cases by addition of Tween 20. There was no early reduction of control by glyphosate at 0.21 kg/ha on the grass species when dicamba at 0.11 kg/ha was applied sequentially at various times in relation to glyphosate. Combinations of glyphosate with 2,4-D, dicamba, MCPA, bromoxynil–MCPA, or bromoxynil were as effective as or more effective for control of rape than the various broad-leaved weed herbicides applied alone. Rape showed a high degree of tolerance for dicamba.

*Study of the interaction between glyphosate and various herbicides for broad-leaved weed control.* The effects of several herbicides for broad-leaved weed control on phytotoxicity of glyphosate to wheat, barley, and wild oats were studied in the greenhouse. In tank mixtures, dicamba, 2,4-D, and bromoxynil reduced the phytotoxicity of threshold rates of glyphosate on all three species. With increasing rates of the herbicides for broad-leaved weed control relative to a fixed rate of glyphosate, there was a general trend toward increased antagonism. Increasing glyphosate rates above the threshold level in mixtures containing a fixed rate of herbicides for

broad-leaved weed control overcame the antagonism. Both the inert and active ingredients of 2,4-D amine and ester seemed to be involved in the antagonism. There was no reduction in glyphosate phytotoxicity on the annual grasses when 2,4-D or bromoxynil was sprayed sequentially at various times in relation to glyphosate. When droplets of bromoxynil and glyphosate were placed side by side on a leaf, glyphosate phytotoxicity was not reduced, whereas when the two herbicides were mixed and applied as one droplet, glyphosate phytotoxicity was reduced considerably. The reduction in glyphosate phytotoxicity caused by tank mixing with herbicides such as 2,4-D, bromoxynil, and dicamba may be due to a physical or chemical incompatibility within the tank mixture rather than to a biological interaction in the plant.

## **SOLONETZIC SOIL SUBSTATION, VEGREVILLE, ALTA.**

### **Gypsum and ammonium nitrate for amelioration of a Black Solonetz soil**

Heavy rates of gypsum surface applied alone and in combination with ammonium nitrate to a Black Solonetz under dryland conditions favorably affected the chemical properties of the Ap and Bnt horizons and increased water penetration into the Bnt. Gypsum alone was equally as effective in ameliorating the soil as the combined treatment.

### **Calcium deficiency in some Solonetzic soils**

Analysis of displaced soil solutions, at half available moisture percentage, indicated that Mg to Ca (Mg/Ca) ratios and Ca to total cation (Ca/TC) ratios ranged from 0.35 to 3.64 and 0.74 to 0.04, respectively, in the A and B horizons of the Solonetzic soils studied. The growth of barley in these simulated solution cultures began to decline when the Mg/Ca ratio in solution exceeded 1.0, or when the Ca/TC ratio was lower than 0.15, regardless of levels of salinity, concentrations of Ca or Mg, or differences in ionic strength. Reduced growth was followed by symptoms of Ca deficiency. Growth of barley in soil from various horizons of Solonetzic soils supported the results found in solution culture. Calcium amendments to soils with low Ca/TC ratios or high Mg/Ca ratios in the soil solution increased growth and prevented Ca deficiency.

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# Research Station

## Lethbridge, Alberta

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 Hydrology  
 Soil microbiology  
 Drainage engineering

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 D. G. KELLER, B.Sc., M.S., Ph.D.  
 Resigned 7 August 1979  
 K. K. KROGMAN, B.Sc., M.Sc.  
 Retired 27 December 1979  
 R. I. LARSON, D.Sc., F.A.I.C., B.A., M.A., Ph.D.  
 Retired 29 May 1979  
 L. E. LUTWICK, B.Sc., M.Sc., Ph.D.  
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 H. MCKENZIE, B.S.A., M.Sc., Ph.D.  
 Deceased 22 August 1979  
 U. J. PITTMAN, B.Sc.  
 Retired 27 December 1979  
 M. G. ROACH  
 Transferred 27 April 1979 to Revenue Canada—  
 Taxation  
 R. B. ROGERS, B.Sc., M.Sc.  
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 Black fly ecology  
 Irrigation efficiency  
 Spring wheat breeding  
 Grassland soils  
 Spring wheat breeding  
 Dryland agronomy  
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Transferred to Western Region  
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Economics of forage and  
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*National Research Council of Argentina postdoctorate fellow*

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Rumen microbiology

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## INTRODUCTION

Scientists of the Research Station at Lethbridge are engaged in a wide variety of research that has both local and national application. Research activities range from local cultivar and fertilizer trials to development of improved crop cultivars, basic research on the chemical structure of pesticides, and participation in the national dairy cattle breeding project. Scientists of six discipline-oriented research sections are organized into multidisciplinary teams to meet Department objectives.

In the brief reports that follow, there is a discernible focus on manipulation of the agricultural environment through biological means. Plant breeding to develop resistance to insects and diseases is a traditional means of biological control, but there are also many new approaches. The control of mosquitoes through fungal infection of larvae, inducing resistance to warble flies in cattle through immunological means, the use of natural or synthetic pheromones to monitor or disrupt insect flights, and the development of synthetic pyrethroid insecticides to simulate naturally occurring ones are other examples. Research on  $N_2$  fixation in leguminous and nonleguminous crops will help to limit the need for manufactured fertilizer, and integrated pest management studies will lead to greatly reduced need for insecticides on some crops.

The prairie potato breeding project became fully operational this year. The project is based at Lethbridge, but is cooperative with provincial departments of agriculture in Manitoba, Saskatchewan, and Alberta, and is closely integrated with the national program at Fredericton, N.B.

Some additional highlights were the discovery of the reproductive stage of the low-temperature basidiomycete that causes snow mold damage to overwintering plants, conclusion of the black fly control research on the Athabasca River, further clarification of the role of the bacterial population that inhabits the rumen wall of sheep and cattle, characterization of the annual growth forms of the troublesome Eurasian water-milfoil, and determination of the yield potential of grain sorghum under a wide range of soil moisture conditions.

There was a significant reduction in staff during the year with the departure of nine scientists, some of whom had made outstanding contributions to Canadian agriculture over many years. Of special regret was the death of Dr. Hugh McKenzie in an automobile accident on active duty.

This report summarizes some of the main research results of 1979. Further detailed information may be obtained from the scientists or from publications listed in this report. Correspondence or requests for reprints should be addressed to: Research Station, Research Branch, Agriculture Canada, Lethbridge, Alta. T1J 4B1.

J. E. Andrews  
Director

### ANIMAL PARASITOLOGY

#### Biting flies

*Mosquitoes.* *Coelomomyces psorophorae* Couch, a fungal pathogen successfully cultured in the laboratory, was tested in field trials for practical biocontrol of *Culiseta inornata* (Williston) in irrigated pastures. Infection rates were compared in ponds inoculated with three different stages of the life cycle of the pathogen. Inoculations produced mortality rates of 3.6% with infected 6 day copepod intermediate hosts, 28% with zygotes from infected intermediate hosts, and

0.4% with resistant sporangia at the 'go' stage. Results indicate that the zygote is the most effective stage for dispersion of the pathogen and for maximum potential in the practical biocontrol of mosquitoes under field conditions.

*Black flies.* The multidisciplinary inter-agency program on the control of *Simulium arcticum* Malloch in the Athabasca River was concluded with an analysis of pesticidal efficacy and environmental impacts during 5 yr consecutively. Black-fly control and environmental impacts of the pesticide were

highly dependent on hydraulic conditions in the river during treatment. Populations of black-fly larvae were reduced about 95–99% for a distance of 160 km downstream by a single injection of methoxychlor at a concentration of 0.3 ppm for 7.5 min. Optimum control depended on rates of river discharge and current velocity sufficient to maintain high concentrations of silt and detritus particles in suspension throughout the infested course of the river. Two injections in spring to cover a minimum of 250 km of infested river below the town of Athabasca are necessary to reduce the adult infestations in adjacent farming areas by 70%. Spring applications of pesticide were ineffective in reducing invasions by adult flies during subsequent years with no treatment. Massive hatchings of eggs are initiated annually by the scouring action of spring and early summer floods and the extensive associated movement of the bedload in the river.

From comparative analyses of nontarget taxa in the 3 yr with pesticidal applications and 2 yr with no treatment, it has been concluded that an annual spring treatment scheduled for optimum control of *S. arcticum* may be applied with an acceptable level of risk for fish and the invertebrate food chain. No detrimental accumulation of pesticidal residues could be detected in water, river bedload, or delta deposits in a complete residue survey of the river system during the year following the last treatment.

On the basis of the results of the program, recommendations for abatement of black flies in large rivers have been developed.

#### **In vitro culture of larvae of warble flies**

First-instar larvae of *H. lineatum* were reared in vitro from hatch to molt in TC199 plus 10% fetal calf serum at 36–37°C. The mortality was high but development time, 224–245 days, and final size of larvae, 15–18 mm length, were the same as in cattle. For the first 30–90 days, the tiny larvae were very active while accumulating stores of collagenase in the midgut. Then, up to 210 days, they were relatively inactive and produced small quantities of collagenase from the mouth but nothing from the anus. Thereafter, larval activity resumed with much twisting of the stoutly spined posterior end while collagenase was emitted copiously from the anus and a little from the mouth. Before molting,

the larvae again became inactive and developed second-instar tissues. These events reflect: the initial migration through connective tissues to the host's esophagus; the long period of larval inactivity in the esophageal submucosa, when the larval hindgut is plugged by a solid cell barrier; migration to the host's back and cutting the breathing hole, aided by the anal flow of collagenase; and the final settling of the larva to molt in the warble location. High levels of host antibody occurring during the last active period might also be in response to the increased flow of collagenase and metabolites from the larva.

#### **Sustained release of growth regulators for control of horn flies and house flies**

A variation of feed-through treatment of flies breeding in cattle manure is the sustained-release bolus of insect growth regulator. Boluses containing 10% diflubenzuron were given to young beef heifers on pasture and in feedlot and evaluated against horn fly and house fly larvae by bioassay. They resulted in 100% mortality of horn fly larvae for 16 wk on pasture and 17 wk in the feedlot, but without affecting the eggs. After the period of complete control, a few deformed nonviable puparia appeared, then normal puparia that produced normal flies. The house-fly trials were less effective and gave more variable results. Larval mortality from cattle on pasture, corrected by Abbott's formula, averaged 82.4% for the first 6 wk and 63.7% the next 6 wk. In feedlot cattle, the corrected control averaged 80.4% for the first 12 wk, after which control was ineffective. Slow-release boluses control horn-fly populations through most of the season but provide effective house-fly control for a shorter period.

#### **Preventive treatment for tick paralysis**

Since benzene hexachloride has been banned and the supply of its gamma isomer, lindane, is also tenuous under restricted patterns of use, alternatives have become necessary for effective prevention of tick paralysis. Permethrin formulations were compared to the present recommendation of 0.25% lindane in field trials of cattle exposed to paralysis by the Rocky Mountain wood tick at Douglas Lake, B.C. Permethrin as a 1% pour-on or 0.5% spray was an effective replacement for lindane. The 0.0125% spray proposed in registration for other livestock

pests was insufficiently persistent for the tick period.

### Toxicology and efficacy of pesticides

*Phosmet.* A pour-on treatment with phosmet at a dose of 25 mg/kg was 99.4% effective for systemic control of cattle grubs in yearling steers and also provided control of the short-nosed cattle louse on heavily infested 'carrier' cows. The louse control was 74% (range 69–88%) up to 55 days posttreatment.

No signs of phosmet poisoning were discovered in treated steers and cows. The whole-blood cholinesterases (ChE) were reduced significantly in the steers 2–7 wk after treatment, with a maximum reduction of 31.3% occurring 2 wk posttreatment. The ChE were also depressed significantly in cows to a maximum of 28.8% at 1 wk posttreatment. However, with the gradual improvement in the blood values of the cows, which were anemic at the time of treatment, the ChE were restored to the normal level by 13 days posttreatment.

*Permethrin.* Sprays with 0.05% permethrin at 4.5 L per head and a pressure of 28 kg/cm<sup>2</sup> reduced horn-fly infestations by 92.9% (range 78.6–99.8%) for 28 days when the treatment was applied to each animal in a herd of 12 yearling steers. Infestations were also reduced by 87.3% (range 71–100%) for only 14 days when the treatment was applied to three steers in a separate herd of 12 yearling steers.

Treatments provided no barrier to horn flies landing on cattle, but they prevented flies from taking a blood meal. Landing rates of flies were the same on treated and untreated animals throughout the experimental period of 20 days. Of the number of flies landing, 6.5% (range 0–22) and 16.9% (range 9–23) had taken blood meals up to 8 and 20 days, respectively, posttreatment. The mortality rate was 100% for horn flies landing up to 15 days posttreatment and more than 81% for those landing up to 20 days posttreatment.

*Chemistry.* Research on livestock insecticides has focused on developing the microsomal enzyme system (mixed-function oxidases) for evaluating the metabolism of pesticides, particularly insect repellents. Using buffered suspensions of liver microsomes, the oxidative metabolism of the repellent citronyl was investigated by a variety of biochemical and analytical-chemical techniques. Structures of the observed metabolites were tentatively assigned by instrumental

methods, primarily mass spectrometry, and were confirmed by comparison with authentic samples of the metabolites. Levels of alcohol and epoxide compounds in the metabolic extracts were measured by quantitative gas chromatography.

Although synthetic pyrethroid insecticides (e.g. permethrin) have shown much promise for protecting livestock from biting flies, most are unavailable in pure form. This need for pure samples has resulted in the discovery of a new chemical synthesis for the acid moiety of permethrin. The methodology, involving use of ozone gas and a novel Wittig reaction, was useful in preparing pure samples of these compounds from chrysanthemic acid.

## ANIMAL SCIENCE

### Beef cattle

*Testicular development in young beef bulls.* The relationship between paired-testes weight and scrotal circumference was examined in 335 yearling and 2 yr old Hereford and Angus bulls. The equation best describing these data is  $Y = -722.3 + 36.5X$  ( $r = 0.95$ ), where  $Y$  is paired-testes weight in grams and  $X$  is scrotal circumference in centimetres. Scrotal circumference in young beef bulls is an excellent predictor of testicular weight or size. Differences in scrotal circumference due to breed were examined in 1984 yearling beef bulls of eight breeds completing 1140 day growth-performance tests. The average scrotal circumferences by breed were Aberdeen Angus 35.9 cm, Blonde d'Aquitaine 33.9 cm, Charolais 34.7 cm, Hereford 34.8 cm, Limousin 32.1 cm, Maine Anjou 35.8 cm, Shorthorn 34.5 cm, and Simmental 38.2 cm. Beef breeds differ considerably in testicular development at 1 yr of age. The heritability of the scrotal circumference trait of yearling beef bulls was 0.69 as estimated across all breeds.

*Effect of dietary energy on beef bull fertility.* A 3 yr study to examine the effects of high- versus low-energy diets (daily digestible energy ca. 630 versus 500 kJ/kg  $W^{0.75}$ , where  $W$  is the body weight) on the reproductive capacity of 120 young Hereford and Angus bulls was completed. The mean paired-testes weights for high- and low-plane 2 yr old Hereford bulls were 479 and 629 g. The corresponding weights for Angus bulls were 527 and 608 g. A significant ( $P < 0.01$ )

interaction for breed  $\times$  energy level of diet was observed in epididymal sperm reserves of 2 yr old bulls. Epididymal sperm reserves expressed on a per-gram-of-testes basis for the low-plane Herefords ( $57.1 \times 10^6$ ) were 46% greater than for the high-plane bulls ( $28.9 \times 10^6$ ). In contrast, low-plane Angus ( $54.7 \times 10^6$ ) did not differ from the high-plane bulls ( $69.1 \times 10^6$ ). High-energy diets appear quite detrimental to 2 yr old Hereford bulls. Epididymal sperm reserves were 39% greater ( $P < 0.01$ ) in 2 yr old Angus bulls than in Hereford bulls of the same age. No differences due to dietary energy or breed were found for total testicular lipid. The mean total lipid per gram of testicular parenchyma was 25.72 mg. Bulls fed high-energy diets had 32% more ( $P < 0.01$ ) total scrotal lipid (13.81 mg/g of scrotal hide) than bulls on low-energy diets (10.37 mg/g). Total scrotal lipid did not differ between the Hereford and Angus breeds (12.95 and 11.23 mg/g;  $P > 0.05$ ). High levels of scrotal lipid resulting from high dietary energy may impair normal thermoregulation and spermatogenesis.

*Feeding programs for Charolais-Hereford steers.* Charolais-Hereford steer calves averaging 253 kg were assigned to one of five feeding programs until they were marketed at about 521 kg. The all-concentrate diet was fed to obtain a low (L), medium (M), or high (H) rate of gain. The feeding levels were arranged to provide five feeding programs of LMH, HML, MMM, HHH, and LLH, with the first two periods each being 12 wk and the final period lasting until the steers reached the target market weights. The rate of gain of group LMH was 1.01 kg/day, HML 0.91 kg/day, MMM 0.95 kg/day, HHH 1.10 kg/day, and LLH 0.92 kg/day. An average of 106 MJ of digestible energy was required per kilogram of gain and was similar among groups. The average dressing percentage was 57.3% and similar among groups. Steers on the HHH program yielded the fattest carcasses with 1.49 cm of backfat at the 11th-12th rib (used for grading). The backfat of steers on the LMH program was 1.22 cm, HML 1.01 cm, MMM 0.99 cm, and LLH 1.15 cm. All steers graded A1 or A2 except 25% that graded A3 (fat) in the HHH group.

*Feed use for calf production by 2 yr old crossbred beef heifers.* Simmental  $\times$  Angus (SA), Charolais  $\times$  Angus (CA), Hereford  $\times$  Angus (HA), and Jersey  $\times$  Angus (JA) heifers that consumed 10% more energy than

considered adequate for normal growth and reproduction were heavier, produced more milk, and weaned heavier calves in the first lactation than those consuming the 'normal' level of energy. Calves from dams on the two levels of energy intake had similar efficiencies in converting energy that they obtained from milk and creep feed to preweaning weight gain. However, the digestible energy (DE) consumed by the dams or by the dams and their calves per kilogram of calf weaned at 200 days of age was greater for dams on the higher energy intake.

Daily consumption of DE during the lactation averaged 100 MJ for SA and CA, 91.3 MJ for HA, and 94.2 MJ for JA heifers. Daily production of energy from milk was greater ( $P < 0.05$ ) for JA than for CA or HA heifers (22.2 versus 17.6 and 18.4 MJ) but not significantly greater than for SA (20.1 MJ). Calves from CA and HA dams compensated in energy intake for the lower milk production of their dams by consuming more creep feed than calves from SA or JA dams. Consumption of DE per kilogram of calf weaned averaged 86.3 MJ for the dams and 101 MJ for dams and calves with no significant difference among the four breed types of dams.

*Feedlot bloat.* Our earlier studies showed that bloat is greatly reduced when cows are fed a coarse rather than a fine particle size diet. When salt was increased from 0.5% to 4.0% in a fine particle, all-concentrate feed, the rumen fluid characteristics associated with bloat (frothy conditions, high viscosity, and low pH) were reduced. Cows fed a 0.5% salt diet had large numbers of broken bacterial cells and cells with slimy materials in their rumen contents compared with those fed the 4% salt diet. The constituents of these broken cells, along with the bacterial slime, produce a highly viscous rumen fluid in which the gas becomes trapped. The extra salt increased water intake and thus the flow of water through the rumen. Both factors increased the flow of material from the rumen and appeared to alter fermentation in such a way as to oppose development of conditions that lead to bloat. Although 4% salt in the diet reduced rumen fluid factors associated with bloat, the addition of salt should be considered a temporary means of reducing bloat because of cost and expected reduction in feed intake.

*Rumen microbiology.* The discovery of a distinct, partially facultative, bacterial population on the rumen wall helps us to understand the important interface between the anaerobic conditions in the lumen of the rumen and the patently aerobic surrounding tissue. These bacteria are products of a highly specific ecological niche where the adherent bacteria rely on the host animal for nutrition and the host uses the symbiotic relationship in respect of an essential enzyme activity. Specifically, this bacterial population adhering to the rumen wall contributes to the overall process of ruminant digestion in at least three ways. First, it converts the waste protein of dead epithelial cells to subsequently usable bacterial biomass; second, it produces the urease that converts urea to nutritionally valuable ammonia; and third, it facilitates and partially regulates urea transport from the blood across the rumen epithelium.

## Sheep

*Out-of-season breeding of sheep.* Six consecutive production cycles, each of 212 days duration from the beginning of breeding in one cycle to the beginning in the next, were completed with Rambouillet and Suffolk ewes. One group of each breed was maintained under natural light conditions (control) and three groups of each breed were under the influence of various light treatments applied regularly in a rhythmic fashion within each production cycle. Comparison of conception rates between production cycles, breeds, and treatments showed that only in the second production cycle (breeding in June) were the conceptions in control ewes of both breeds significantly lower than those in ewes on altered light treatments. The most meaningful result was the effect of light treatments on prolificacy. Treatment 3 (106 days with light for 16 h/day and 106 days with light for 8 h/day) gave significantly higher prolificacy than the control and treatments 1 (106 days with light for 8 h/day starting 65 days before breeding) and 2 (42 days with light for 16 h/day, then light reduction at 21 min/wk for 160 days). Rambouillet and Suffolk control ewes produced annually 179 and 174 lambs per 100 ewes exposed to rams. Corresponding productions were 200 and 197 for treatment 1, 193 and 226 for treatment 2, and 223 and 242 for treatment 3.

## Poultry

*Growth responses of chicks fed fababean diets.* Fababeans were fed to broiler chicks from 1 to 28 days of age in four experiments. In experiment 1, where fababeans were the sole source of supplementary protein, body weights of chicks fed the different cultivars differed significantly and ranged from Marisbead (571 g) > Strubes > Pavane > Ackerperle > Kleinkoernige (456 g) but none of the fababean diets supported gains equal to that obtained with soybean meal diets (670 g). In experiment 2, supplementary protein source (soybean meal and fababean), dietary protein level (18 and 22%), methionine level (0.0 and 0.3% added), and lysine level (0.0 and 0.3% added) significantly affected body weights of chicks. Significant first-order interactions were obtained but chicks fed fababean diets were always lighter than those fed soybean meal diets. In experiment 3, four cultivars of fababeans (Marisbead, Ackerperle, Diana, and Kleinkoernige) grown under various N fertilizer treatments were tested. There were no significant differences in chick weights among fababean cultivars or among cultivars grown under different N treatments. When fababeans supplied 25% of the total protein in 22% protein diets, they supported rapid weight gain (701 g) but did not equal soybean meal diets (761 g). In experiment 4, where isocaloric diets of two energy levels were used, fababeans at 20 or 40% of the diet supported as high body weights as soybean meal in the low-energy diets. In high-energy diets, 20% fababeans also supported as high body weights as soybean meal but the 40% fababean diets did not. In none of the experiments did fababeans support as low a feed-to-gain ratio as soybean meal.

*Rapeseed meal diets for broiler chicks.* The introduction of new rapeseed cultivars has increased the interest in the use of rapeseed in poultry diets. An experiment was conducted to determine the effect of Tower rapeseed meal in combination with conventional (13.5% protein) and high-protein (21%) wheats on growth and feed conversion of male broiler chicks. Twelve diets were formulated to contain the two wheats in soybean meal diets and rapeseed meal diets at various energy levels. Half the diets contained 0.3% supplemental lysine and half did not. Body weights of chicks fed conventional or high protein wheat in soybean meal diets did not

differ significantly, regardless of lysine supplementation. However, feed-to-gain ratio improved significantly when lysine supplementation was used in the high-protein wheat diet. Chicks fed conventional wheat in the rapeseed meal diet without supplemental lysine were lighter and had higher feed-to-gain ratios than those fed either of the wheats with soybean meal. Supplemental lysine improved growth only slightly. The high-protein wheat in rapeseed meal diets without lysine supplementation resulted in body weights that were significantly below those of any of the other diets, but when the diets were supplemented with lysine, growth rate was improved and was not significantly lower than those of the soybean meal diets. Feed-to-gain ratio was significantly improved by the addition of lysine to the diet containing high-protein wheat and rapeseed meal. Adjustments in energy levels (to give isocaloric diets) did not improve the body weight of chicks fed the conventional wheat plus rapeseed diets but did improve the feed-to-gain ratio. However, even with equal energy in the diets, the rapeseed meal diets did not support as low a feed-to-gain ratio as the soybean meal diets.

## CROP ENTOMOLOGY

### Forage crop insects

*Alfalfa seed crops.* The cooperative integrated pest management program on alfalfa grown for seed has been well accepted in the Brooks area, and total area in this program increased over 1978. Insect control procedures were initiated according to the program, and as a result, the area treated with insecticide decreased from 1978.

Weekly sampling of alfalfa fields revealed that populations of alfalfa weevil were greatly reduced from 1978 levels, possibly due to the cold winter with minimal snow cover. Thus chemical control of the weevil was reduced by about 75% from that applied the previous year. Ecological studies showed that the overwintering adult weevils became active at the same time as they did in 1978, but egg laying and larval development were delayed 2-3 wk.

Populations of plant bugs remained at 1978 levels but numbers of lygus and aphids were substantially higher. Populations of ladybird beetle and damsel bug predators increased whereas pirate bugs remained at the same level this year as in 1978.

*Alfalfa forage crops.* The nutrient values for animals of forages from alfalfa, oats, and broad bean were not affected when infested with pea aphids and grain aphids, *Metopolophium dirhodum* Walker. The aphids contained similar amino acids to those in the host plants. Protein quality of the aphids was similar to alfalfa and oats but slightly lower than broad beans, and more protein and fats occurred in aphids than in host plants. Aphid-infested, 3 wk old alfalfa, when subjected to cold-hardiness tests, produced small crowns, less cold-hardy plants, and reduced plant height and top weight. Pea aphid resistant cultivars of alfalfa, Anchor, Dawson, Kanaga, Messila, Team, and Washoe, as well as aphid-tolerant Titan, survived eight winters including the cold winter of 1979 and can be considered winter-hardy to southern Alberta conditions.

*Pollinators.* In studies with pollinators, a model has been developed to assess the population of alfalfa leafcutter bees required to adequately pollinate alfalfa. It was assumed that the probability of a visit to a particular flower can be described by a Poisson distribution in which the mean was determined jointly by the densities of both flowers and bees, the visitation rate, the time available for flower visits, and the overall probability of a flower being visited or not. In studies to date, 50 000 bees per hectare were considered optimum from various ratios of bee to area tested, with a visitation rate as low as 1.8 florets per second and florets available for 6 days.

The pollination requirements for cicer milkvetch were investigated under caged tests. The number of seeds produced per pod varied with the pollinators: *Bombus nevadensis* Robertson, 7.9; *B. appositus* Cresson, 6.0; *B. huntii* Greene, 5.9; alfalfa leafcutter bees, 3.5; honey bees, 3.3; and pollinators excluded, 0.

An analysis of 19 yr data from several locations indicated that only 30% of bumble bee colonies established in artificial domiciles produced sexuals. In colonies not producing sexuals, 75% were abandoned before the first brood of workers was produced and the inquiline *Psithyrus* caused only 5% of the abandonments. In colonies producing workers, 42% losses were caused by *Psithyrus*.

*Chemical control.* In studies with mature alfalfa of insecticide penetration of crop canopies, 50% more of the applied insecticide

reached the canopy when applied by ground equipment than by aircraft. With aircraft application at 22 and 112 L/ha and with ground equipment at 56 L/ha, 70% of the insecticide was recovered from the top 15 cm of the canopy. When ground application was increased to 112 L/ha, crop canopy penetration was significantly better. Preliminary tests on insecticide toxicity to leafcutter bees indicated the males were more susceptible than females and contact application was more toxic than foliar application.

## Cutworms

*Sex attractants.* The chemical identification of pheromone-like compounds contained in washes from calling females of the redbacked cutworm showed that seven acetates were structurally similar to known lepidopteran pheromones. These compounds were identified by high-resolution glass-capillary gas chromatography coupled with mass spectrometry and a recently developed electroantennographic detection system. Field evaluation of several blends of synthetic chemicals involving the seven acetates established that a four-component blend attracted the largest number of male moths. This synthetic sex pheromone blend provided a species specific, inexpensive, and extremely sensitive trap bait for monitoring the population densities of redbacked cutworm male moths and thus the prediction of possible larval infestations. About 3000 dispensers treated with attractants for 12 species were provided for monitoring experiments being conducted at six Agriculture Canada research stations, in Oregon, and in Switzerland. These attractants, developed at Lethbridge, functioned well and infestations were predicted in three instances.

Density levels of male adults of army, clover, pale western, and redbacked cutworms and *Leucania commoides* Gn. were recorded in sex attractant traps over a wide area of southern Alberta for the 2nd yr. Counts were made for the 1st yr for darksided and variegated cutworm, and for bertha armyworm. This year, larval densities of the species recorded in 1978 were extremely low and were not related to the numbers of adults collected. However, catches increased by 15–173% for all species except clover cutworm, which was reduced by 64%. Moth numbers based on traps emptied at 2 wk intervals did not differ significantly from counts at 1 wk

intervals but traps unattended for the whole flight period were unsatisfactory.

*Chemical control.* The synthetic pyrethroids are showing potential as effective chemicals for cutworm control. Laboratory tests with eight pyrethroids to control larvae of army, redbacked, and pale western cutworms indicated their relative order of toxicity as oral poisons as: decamethrin (10 times more toxic than endrin), permethrin, cypermethrin, and FMC 26021 (Food Machinery Corp.) (twice as toxic), AC 222705 (American Cyanamid), fenpropanate, and fenvalerate (1.2–1.5 times) with FMC 18739 (Food Machinery Corp.) equal to chlorpyrifos and one-third as toxic as endrin. When the pyrethroids were tested topically, their toxicity increased 2–10 times whereas both endrin and chlorpyrifos were half as toxic as contact poisons. In greenhouse tests with bare soil and in limited small plot tests, the pyrethroids at 0.07 kg/ha were as effective as endrin at 0.28 and chlorpyrifos at 0.56 kg/ha.

## Grasshoppers

*Population studies.* The recent decline in grasshoppers over the period 1974–1978 was reversed in 1979. The population of adults increased 76.6% from the province-wide level of last year. Lightly infested areas (1.2–2.5 grasshoppers per square metre) increased from 12 611 km<sup>2</sup> to 29 013 km<sup>2</sup> with this increase occurring north of the Bow and South Saskatchewan rivers. South of these rivers, the areas infested decreased. There was a decline in areas of moderate infestation (2.5–5.0 grasshoppers per square metre), which occurred as small enclaves within larger lightly infested areas. These moderate infestations occurred northeast of Lethbridge, northwest of Empress, and southeast of Wainwright on the Saskatchewan border. Late summer and early autumn were warm and dry, conditions that favor grasshopper reproduction, suggesting that populations will be higher in 1980 unless weather conditions are detrimental for grasshopper survival.

Grasshopper censuses taken over 16 yr at the Onefour Range Substation near Manyberries were analyzed. Published information on the phenologies of the species, their feeding preferences, the forage value of their diets, the habitat preferences, and causes of damage to rangeland were used to assess the potential for economic damage for 17 of the more abundant species.

*Chemical control.* In laboratory tests with pyrethroids, control of fifth-stage nymphs of *Melanoplus bivittatus*, *M. sanguinipes*, and *Camnula pellucida* was more variable than that obtained with cutworms. Simulated field tests in 1979 indicated that fenpropanate at 0.07–0.14 kg/ha controlled nymphs of each species as effectively as dimethoate at 0.42 kg/ha; fenvalerate and cypermethrin gave unsatisfactory control of *M. bivittatus* and *C. pellucida* and permethrin was ineffective at all rates tested.

A significant phytotoxicity in barley was noted when carbofuran, at grasshopper control rates, was applied within 5 days of propanil or when the chemicals were tank mixed. This phytotoxic effect (leaf yellowing) increased tillering, delayed maturity, and was accentuated with reduced soil moisture levels.

### Sugar beet insects

Data from a field experiment designed to forecast levels of larval infestations from numbers of webworm moths trapped indicated that a high-density population of males, averaging 780 per trap over a prolonged flight season, produced a larval infestation causing significant damage in sugar beets. Larvae averaging 11.9 per sweep reduced beet yield by 22 t/ha. Electroantennogram studies indicated that excised antennae of male beet webworm moths, less than 3 days old, had weaker responses and shorter reaction life than did those from older moths. The species-specific attractant *E*-11-tetradecen-1-yl acetate consistently produced stronger antennal responses than 40 C<sub>10</sub> to C<sub>16</sub> acetates. Its *cis*-isomer, a known inhibitor, produced similar but weaker reactions.

### Potato insects

Studies on the economic threshold of Colorado potato beetle indicated that, in caged plants, larval populations of 40 larvae per plant were required to reduce weights of mature tubers significantly.

### Insecticide residues

A microplot field experiment was conducted to determine the persistence and possible movement of fenvalerate residues in soil. Initial recovery was 97.5% of the amount applied at 150 g/ha. Fenvalerate residues were found to persist mainly in the 0–2.5 cm layer with a half life of 6 wk. Residue levels in October (after 16 wk) were 15% of the

amount applied and decreased to 11% the following spring. Fenvalerate was not readily leached downward and lateral movement was minimal. It was concluded that residues were immobilized by strong adsorption to Lethbridge loam and this insecticide would be environmentally acceptable under southern Alberta conditions.

No residues of fenitrothion were found in harvested grain when applied to wheat at 0.56–0.84 kg/ha at 12, 17, and 20 days before harvest. Residues in straw at harvest contained 20% of the total applied chemical, but they dissipated rapidly.

## ECONOMICS

### Poultry

*Low-glucosinolate rapeseed meal in diets of growing turkeys.* Low-glucosinolate rapeseed meal (RSM) can profitably replace some portion of other high-protein ingredients in diets of growing turkeys. This economic analysis has revealed that the most profitable diets for turkeys up to 14 wk of age contained between 4.4% and 22.5% RSM. In spite of the lower energy content of RSM, and thus the lower growth rate of birds fed diets containing RSM, it was not always most profitable to supplement the RSM-based diets with fat. Under many price conditions studied, maximum rates of growth did not coincide with maximum profit.

## PLANT PATHOLOGY

### Potato diseases

The effect of humidity and temperature on the persistence of the potato ring bacterium, *Corynebacterium sepedonicum* (Spieck. & Kotth.) Skapt. & Burkh., on storage surfaces was determined by bioassay. Ring rot bacteria were still virulent after 20 mo on jute, polyethylene, and kraft paper held at 10% relative humidity (RH) at either 5 or 20°C, and on plywood at 10% RH and 5°C. However, the bacteria persisted for only up to 14 mo on plywood at 10% RH and 20°C. Persistence decreased at higher humidities.

Virulent ring rot bacteria were recovered from dried, infected potato stems of three cultivars (Netted Gem, Norland, and Warba) after they had been stored in an unheated machine shed for 26 mo. These results show



that ring rot bacteria persisting on contaminated surfaces or in infected dried stems can serve as a source of inoculum unless storage areas, machinery, or other surfaces are thoroughly cleaned and decontaminated.

### Forage diseases

The low-temperature-tolerant basidiomycete (LTB) causes significant snow mold damage to overwintering crops in areas of Western Canada where snow cover is heavy. Over the past 40 yr, failure to observe a reproductive stage in its life cycle has seriously hindered efforts to completely identify the LTB and to develop satisfactory control procedures. Small and short-lived fruiting bodies of an agaricoid basidiomycete were observed recently on necrotic crowns of alfalfa in the greenhouse and in the field where snow mold damage (winter crown rot) by LTB had been diagnosed. The mushroom was identified as *Coprinus urticicola* and was shown to establish a genetic relationship with mycelial isolates of the LTB. This compatibility evidence for the identity of the LTB as *C. urticicola* is supported by observed similarities in cultural features such as hyphal anatomy, colony growth at low temperatures, and autolytic production of hydrogen cyanide.

### Cereal diseases

A bimodal distribution of ratings for common root rot suggested that Canuck spring wheat, a sawfly-resistant variety licensed in 1974, might be a mixture with respect to root rot reaction. That suspicion has now been confirmed by comparing the reaction of Canuck Breeder lines in a controlled-environment root rot test using field soil naturally infested with conidia of *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur. Of the 98 lines tested, 37 were less susceptible ( $P < 0.01$ ) and 53 more susceptible than the parent variety, which had a mean root rot rating of 56%. Of the more resistant lines, 36 were not different ( $P > 0.05$ ) from the moderately resistant check variety, Thatcher, and had a mean root rot rating of 20%. The 53 susceptible lines had a mean root rot rating of 83%. These results indicate that it should be possible to improve the agronomic performance of Canuck by reconstituting it using only the root-rot-resistant lines.

### Cold hardening of wheat

When grown under conditions that induce a high level of hardness, cold-hardy winter wheats have shorter leaves with lower water contents than they do when grown under nonhardening conditions. Among such plants, there is a highly significant rank order correlation between cold hardness and leaf length.

Since cell elongation involves water uptake, the relationship between water content and epidermal cell length was examined to test whether low water content might be the cause of reduced leaf length. Epidermal cell measurements were used because these cells lie in long, regular rows on both surfaces of wheat leaves. Since the reduced leaf length was the result of a reduction in both cell numbers and cell lengths, it is evident that low water content cannot be the only cause of reduced leaf length. Correlations between the lengths or numbers of cells in rows of epidermal cells and cold hardness of hardy plants were much poorer than were correlations of either leaf length or leaf water content and cold hardness.

Either the length or water content of hardened leaves could be used in a preliminary screening test for cold hardness. Since leaf-length measurements require little labor, they should provide a convenient, rapid method for preliminary rating.

## PLANT SCIENCE

### Weed control

*Dandelion control.* In orchardgrass and Troy Kentucky bluegrass, 2,4-D applied in the spring and fall of 1978 provided excellent control of dandelions in 1979. Good control in 1979 was also observed after spring treatments in 1978 with 2,4-D alone (2 kg/ha) or 2,4-D plus dicamba (1.0 + 0.4 kg/ha) and spring plus fall treatments with 2,4-D alone (1.0 kg/ha). Additional data are required to determine whether dandelion control increases grass yields. Velpar was the most effective herbicide for the control of dandelions in legumes but only fair control was achieved.

*Shrubby cinquefoil control.* Picloram pellets (2.2 kg/ha) or velpar grid balls (4.5 kg/ha) provided good shrubby cinquefoil control. Additional data are required to determine whether shrubby cinquefoil control increases forage yield.

*Effect of weed control on establishment of legumes.* Alfalfa, sainfoin, and cicer milkvetch were established in 1978 without weed control, with chemical weed control, or under a barley cover crop. The herbicides used were dichlofop plus 2,4-DB for sainfoin and alfalfa, and trifluralin plus bromoxynil for cicer milkvetch. The total yields of the legumes in 1979 (two cuttings) from the cover crop, untreated check, and herbicide treatments were: 8680, 9050, and 10 390 kg/ha for alfalfa; 6440, 8130, and 9980 kg/ha for sainfoin; and 1510, 2930, and 7018 kg/ha for cicer milkvetch.

*Tolerance of legumes and grasses to new herbicides.* Alfalfa, sainfoin, cicer milkvetch, and alsike clover were tolerant to ethalfluralin and EL5261 (Elanco). Bromegrass, Russian wild rye, and crested wheatgrass were tolerant to propanil, propanil plus MCPA, and cyanazine plus MCPA. Orchardgrass was tolerant to only propanil and propanil plus MCPA. DPC 4189 (DuPont) was toxic to all the legumes and grasses that were tested.

*Sugar beets.* Broad-leaved weed control was excellent with pyrazon. Ethofumesate gave excellent control of volunteer barley, good control of green foxtail, and fair control of broad-leaved weeds. Ethofumesate clearly required the addition of other herbicides for reasonably broad spectrum weed control. Either BAS 9052 (BASF) or dichlofop methyl as postemergence treatments after pyrazon as a preplant-incorporated (PPI) treatment gave outstanding control of green foxtail and broad-leaved weeds.

*Corn.* Preplant disc-incorporation of alachlor, EPTC plus R-25788 (Stauffer), and metolachlor all gave excellent green foxtail control while preemergence harrow-incorporation of metolachlor and alachlor gave only fair control. As early spring (March) applications of the latter two chemicals gave only fair control, they are probably not suitable for fall application. Atrazine (0.8 kg/ha) gave excellent broad-leaved weed control. Postemergence application of 2,4-D ester, 2,4-D amine, dicamba, and bromoxynil all gave very little or no injury to corn.

*Potatoes.* Metribuzin plus EPTC (0.6 + 3 kg/ha) gave 90% control of broad-leaved weeds. A tank mix of metribuzin plus metolachlor (0.6 + 2.5 kg/ha) gave only 60–70%

weed control. Metolachlor plus metobromuron (2 + 1.25 kg/ha) as a PPI treatment, metribuzin (0.6 kg/ha) PPI, and EPTC (4 kg/ha) PPI all provided at least 80% control of wild buckwheat and lamb's-quarters.

*Sorghum.* Atrazine incorporated with a disc provided very good control of volunteer barley even at 0.84 kg/ha. Pre- or post-emergence surface applications of atrazine gave very poor control of volunteer barley. Sorghum showed variable tolerance to dicamba, dichlofop methyl, and difenzoquat.

*Rapeseed.* Rapeseed treated with dinitramine (0.8 kg/ha) and ethalfluralin (0.8 kg/ha) showed about 10–15% thinning on a Lethbridge 1.5% OM soil. Both showed higher broad-leaved activity and better volunteer barley control than trifluralin.

*Growth and development of Myriophyllum spicatum.* Controlled environment chamber studies have shown that Eurasian water-milfoil (*Myriophyllum spicatum*) exhibits two seasonal growth forms. The summer growth form occurs from about 15°C up to 25–26°C and is characterized by a fine, hairlike root system and rapid top growth (2.5–3.7 cm/day). Flowering occurs at water temperatures of 25°C or higher and light intensities in excess of 2.5 klx (16 h photoperiod). The winter growth form occurs at water temperatures below 14°C and growth continues down to 6°C. Maximum winter vegetative growth occurs at 10°C with a coarse, fibrous root growth and a deeply red pigmented top that grows slowly. Growth continues at light levels as low as 1.1–2.2 klx (7 h photoperiod). This winter growth develops adventitious roots at 14°C and the branches then abscise. This autofragmentation at spring water temperatures produces a new inoculum for future infestations. Control may be possible through mechanical and chemical techniques applied in the fall and early winter to kill existing plants and remove potential infestation.

### Special crops

*Screening soybeans for resistance to shattering.* Resistance to pod shattering at maturity in the field is essential for maximizing soybean yields and successful soybean varieties must be shattering-resistant. A laboratory method was developed to screen lines for resistance to shattering. Plants of soybean lines to be tested were grown in a growth

cabinet under high humidity, and pods from mature plants were cut and subjected to the shattering test on the same day. In the shattering test, a compressive force was applied to the pods, held by their stem, until they broke open. The breaking force was recorded on a strip chart on which high peaks imply shattering resistance and low peaks, shattering susceptibility. As pod moisture content influences the force needed to break pods, moisture was measured and adjusted for. A typical shattering-resistant line required a force of 1.7 kg to break the mature pods, while a shattering-susceptible line required a force of only 0.6 kg. Those lines requiring the highest force to break open the pods can thus be selected as shattering-resistant. In this way, all shattering-susceptible lines can be removed early in a breeding program thus permitting yield testing of only those lines that show promise of becoming high-yielding, shattering-resistant varieties.

*Resistance to 'hollow heart' in potato.* The growth patterns of Viking, a potato cultivar resistant to 'hollow heart,' and Norgold Russet, a susceptible cultivar, were studied over an 8 wk period to establish growth characteristics associated with susceptibility. At 1 wk intervals during this period, the leaf area and dry weights of tuber, stem, and leaf were measured. To establish the responses of the two cultivars to moisture stress, a growth chamber experiment was conducted. Six weeks after planting, 12 plants were selected for foliage uniformity and a drought period imposed until wilting occurred. Leaf water potential measurements were made, using a pressure chamber, during the period of maximum daily stress. Data from this study suggest that a major factor associated with resistance in Viking is the ability to attain a far higher leaf water potential than Norgold Russet before wilting occurs. This may also be associated with the superior net assimilation rates observed in Viking. Tuber growth rate does not appear to be a factor contributing to the differing susceptibility in these two cultivars.

*Sunflower hybridization.* Three backcrosses of interspecific hybrids of *Helianthus petiolaris* Nutt. × *H. annuus* L. by cultivated sunflower (*H. annuus*) eliminated meiotic abnormalities evident in the original F<sub>1</sub> hybrids and early backcross generations, and induced male sterility. In vivo pollen germination and pollination tests of male-sterile plants

were normal. Crosses of the male-sterile plants with seven sources of pollen-fertility restorer and one collection of wild *H. annuus* indicated that the sterility was cytoplasmic and different from that presently used in hybrid sunflower production. The inheritance of restoration of pollen shed was complex. Some data indicated that two independent, complementary, dominant genes were required, but others suggested two or three independent, dominant genes.

A second new source of cytoplasmic male sterility was found in backcross plants of interspecific hybrids from the three-way cross (*H. giganteus* L. × wild *H. annuus*) × cultivated sunflower. Two of three restorer sources tested failed to restore pollen shed of male-sterile plants.

Potential male sterility also occurred in backcross plants of interspecific hybrids of the three-way cross (*H. maximiliani* Schrad. × wild *H. annuus*) × cultivated sunflower. The anthers of some plants were highly modified and shed little or no pollen. Trisomic ( $2n + 1$ ) plants with normal anthers also were found. Seed weight of trisomic plants was significantly greater than that of diploid sibs; oil content also tended to be higher.

## Corn

*Variability and trends of corn heat units.* Seasonal accumulations of corn heat units (CHU) were calculated from temperature records of 85 stations in Alberta, Saskatchewan, and Manitoba. The number of years of data varied from 16 to 72. The objectives of the study were to determine how many years of data were necessary to obtain a reliable estimate of CHU for each station and to examine possible CHU trends with time. Stein's two-stage sampling technique was used to show that about 20 yr of data should be used to obtain a reliable estimate of the location mean. When years were taken at random, the number of years of data needed for a location was larger than when taken in sequence. Statistically significant indications of trends in CHU with time were found for only about 11% of the stations. Year-to-year variability was considerably greater than any possible trends in the last century. Means and standard errors of the deviations from the 30 yr mean (1943–1972) were calculated for all stations. Although these data were not independent because of their geographic proximity, there was an indication that CHU totals

have changed in the past half-century. However, future changes in the CHU totals could not be predicted.

*Effect of paraquat-simulated frost on growth and development of corn grain.* Four corn hybrids grown at Lethbridge in 1975, 1976, and 1977 were sprayed with paraquat to simulate killing frosts. Paraquat produced symptoms similar to those of a first killing frost. Interactions among hybrids and treatments were rare for characteristics such as grain yield, test weight, and kernel moisture content. The most pronounced effect of paraquat was that yield was reduced by about 1000 kg/ha for each week before maturity that the simulated frost occurred. Development was not affected as much as yield. Treatments that resulted in a yield reduction of 60% caused only a 15% reduction in test weight. Kernel development was closely related to the accumulation of growing degree-days with a base of 12°C. The simulated frost treatment resulted in a higher kernel moisture content immediately after the treatment, but a slightly higher rate of moisture loss resulted in the 'frost' treatments catching up to the checks and finally having a slightly lower moisture content than the checks. The earlier it was imposed, the greater was the reduction in growth rate of grain caused by the simulated frost treatments. In addition, a very early simulated frost resulted in a longer effective filling period duration (EFPD), and a later imposition of the simulated frost caused a reduction in the EFPD compared to the check treatments. Cob moisture content was relatively constant and decreased at a faster rate than kernel moisture content only after kernel moisture content reached 40%.

### Forage crops

*Cold hardiness and vigor of an alfalfa stand.* The effect on cold hardiness of certain management practices commonly used in southern Alberta was studied for 3 yr. The treatments included applying the last irrigation on 15 August, or on 15 October, or not irrigating the plots at all (dry land). Superimposed on these irrigation treatments were various cutting schedules; three cuts per season with the last cutting date 15 September or 10 October was compared to two cuts per season with the same last cutting dates. Plants were dug up on two occasions in the late fall of 1978 and submitted to freezing tests to determine their cold hardiness. The

various management treatments apparently had no effect on cold hardiness. Total yields were significantly higher from plots cut three times than from plots cut twice per season. The plots were cut on 7 June 1979 to determine the effect of the previous 3 yr of treatments on spring vigor. From the yields, it was evident that a three-cut schedule with the last cut on 15 September significantly reduced the vigor of spring growth, whereas a two-cut schedule with the last cut on 15 September had no detrimental effect. The various irrigation treatments had no effect on spring growth.

From this study, it can be concluded that if alfalfa is to be cut three times a season, cutting dates near 15 September should be avoided as this practice will reduce the vigor of the stand. If only two cuts are taken per season, the date of the second cut is less important.

*Forage production of some native range sites.* Forage production of native range was monitored over a 10 yr period on 22 sites in southern Alberta. Annual variations in dry matter yields were generally low at each site, but six distinct types of rangeland vegetation were detected. Stocking rates calculated on the basis of dry matter production on these sites, which were protected from grazing, were greatly overestimated when compared to dry matter production figures from grazing studies. Further study showed that when stocking rates were based on dry matter yields obtained on moderately grazed areas, the values were very similar to those obtained in grazing trials. Subsequent studies indicated that dry matter production on grazed areas was only 40% of that on ungrazed or protected areas and that stocking rate estimates should be based on 40% of the average forage production obtained on ungrazed or protected areas. The stocking rate estimates also were more realistic when based on total yield of the vegetation than when based on only the grass component of the vegetation.

*Influence of drying methods on protein content and amino acid composition.* Plant materials are usually dried before being analyzed for organic or inorganic constituents. Drying prevents changes in composition through respiration and other physiological activity and allows comparisons among samples to be expressed on a moisture-free basis. In some cases, however, drying methods may influence the end results. To study the effect

of three methods of drying on amino acid composition, forage samples of alfalfa, sainfoin, and cicer milkvetch were dried in a forced-draft forage dryer, a drying oven, or a microwave oven. Dry matter content, protein content, and amino acid composition were determined. The air-drying methods resulted in significant losses of dry matter compared with microwave drying, suggesting that the latter method is preferable for dry matter determinations. Interactions between species and drying method were significant for some of the amino acids but not for methionine, isoleucine, or valine, which are nutritionally limiting for monogastrics. Since protein scores, reflecting protein quality, and protein content of the three legumes were not affected by drying methods, any one of the methods would be satisfactory. However, large numbers of forage samples can be handled most conveniently in a forced-draft dryer.

## SOIL SCIENCE

### Environmental quality

*Waste water irrigation.* Forage plots have been irrigated with municipal waste water for 8 yr at Taber, Alta. Maximum utilization rates of waste water, which supplied the crop water requirements, provided adequate P but insufficient N for grass forage production. Alfalfa had higher yields and higher N uptake than reed canarygrass or brome grass. Grass yields were similar to yield of the alfalfa when double the irrigation rate and N plus P fertilizer were supplied. Soluble salts were leached out of the soil at both irrigation rates and total salt content of the groundwater was reduced.

Rendering plant waste water used to irrigate forage plots near Lethbridge for 3 yr supplied excess N and P for plant growth. Forage yields from waste water irrigated plots were similar to those receiving irrigation water and N plus P fertilizer, and greater than those receiving only irrigation water or water plus soluble carbon. Without supplemental fertilizer, grass yields were restricted by lack of N; alfalfa yield was reduced to a lesser degree, probably due to lack of P.

*Nutrient levels of surface and groundwaters: Effect of feedlots.* Surface and groundwaters have been monitored at four cattle feedlots in southern Alberta since 1974. Two feedlots were near streams, one was near

a lake, and one was not near any surface body of water. There was no evidence of pollution of the streams and lake with N, P, and salts from the feedlot effluent, even though the potential exists. Runoff was not a major problem at any of the locations because of the capacity for manure to adsorb and retain large amounts of water before drainage occurred and because most of the pens were on flat land or had restrictions that held most of the excess water in place. Isolated and erratic incidences of N and P contamination of groundwater were found, but did not seem to pose a threat to the environment.

### Soil-crop relationship

*Seeding equipment for zero tillage.* The effectiveness of several commercial seeders was assessed on a silt loam soil at Lethbridge over a 7 yr period on fields receiving chemical weed control instead of tillage. The double- and triple-disc press drills generally failed to penetrate untilled surfaces when surface residue exceeded about 3700 kg/ha. Hoe openers penetrated the soil satisfactorily but failed to clear heavy residues when stubble and straw lengths were excessive ( $> 25$  cm). In 2 of 7 yr, yields of spring wheat on plots seeded with the double- and triple-disc drills were greater than those seeded with the wide-spaced hoe drill (1159 versus 721 kg/ha in 1969, and 667 versus 573 kg/ha in 1973). Yield differences were primarily due to wild oats, which germinated because of the tillage action of hoe openers.

*Response of Galt barley to irrigation, applied fertilizers, and magnetic seed treatment.* Galt barley grown from magnetically treated seed on well-fertilized irrigated land produced about 5300 kg/ha, or 31 kg/ha more than that grown from nontreated seed on dry land of low fertility. On the average, magnetic seed treatment accounted for about 11% of the increase in yield. Magnetic treatment had the greatest effect under irrigated and fertilized conditions (17% increase) and least on fertilized dry land (4% increase).

*Effect of dry land rotations on decomposition of organic matter.* Individual rotations had little effect on the chemical composition of organic residues on the soil surface but had a marked effect on the decomposition and nature of subsurface plant residues over a 19 mo period. The cultivated soils after 63 yr contained 47% less C, 46% less N, 53% less

polysaccharides, 100% more solvent-extractable C, 49% more resin-extractable C, and a slightly higher pH than the soil from the adjacent native grassland.

*Soil properties of native range.* Gas chromatographic patterns of organic-solvent-soluble constituents present in alkaline hydrolysates of organic matter (OM) from soils underlying native range and crested wheat-grass are qualitatively but not quantitatively similar. The major peak, with a retention time of about 31 min, was identified as bis(2-ethylhexyl) phthalate. Larger quantities of the extracted compounds were obtained from the native range than from the crested wheat-grass soils. Fifty years was not long enough for OM of soil cultivated for only 5 yr to regain its original quantitative chemical composition under the prevailing climatic conditions.

*Associative dinitrogen fixation with wheat.* The modification of the genotype of Cadet and Rescue cultivars of spring wheat by disomic chromosome substitution altered the amount of plant N derived from associated  $N_2$  fixation. With the exception of the C-R5B lines, inoculation of the parent Cadet or its substitution lines with either *Bacillus polymyxa* or *Azospirillum brasilense* increased plant dry matter and total N yield in a phytotron experiment. Rescue lines were unaffected by inoculation unless genotypically altered by substitution of the 5B or 5D chromosomes from Cadet. Different substitution lines reacted uniquely to inoculation with the specific bacteria: C-R2A and R-C2D promoted greater  $N_2$  fixation by *A. brasilense* but C-R5D, R-C5B, and R-C5D encouraged greater  $N_2$  fixation by *B. polymyxa*. Both bacteria had high and identical levels of  $N_2$  fixation with the C-R2D lines, and neither bacterium fixed  $N_2$  when grown in association with the C-R5B, Rescue, or R-C2A lines. The ability of these lines to support  $N_2$  fixation in the field was inhibited by the presence of soil N, but  $^{15}N$  analyses indicated that inoculation increased the N yield of selected lines by 10–15%.

*Dinitrogen fixation by rhizobia of beans.* Eleven cultivars of common bean inoculated with a commercial strain of *Rhizobium phaseoli* were grown in an N-free medium at two temperature regimes corresponding to mid-May or early June seedings. Time of

seeding affected  $N_2$  fixation: early June seedlings fixed more  $N_2$  than mid-May seedlings when grown for the same period of time. Cultivars differed in their abilities to support  $N_2$  fixation and the amount of  $N_2$  fixed was correlated with leaf area and leaf and shoot weights. It is proposed that the relationship between  $N_2$  fixation and these quantitative yield characters may help bean breeders in selecting plants with superior  $N_2$ -fixing abilities. Redkloud, a kidney bean, was the best fixer at both temperature regimes. Several of the smaller beans were as efficient, on a weight basis, as the larger seeded ones.

Growth habit of the cultivars, whether determinate or indeterminate, climbing or bush, gave no specific advantage in  $N_2$  fixation under the conditions of the experiment. Nor was there any relationship between the cold temperature tolerance and the  $N_2$  fixed in the plant.

### Irrigated soils

*Sixty-six-year trends in irrigated crop yields.* Spring wheat, barley, and oats have been grown each year in an irrigated 10 yr rotation since 1910. The regression coefficients of wheat, barley, and oat yields were calculated to be 0.020, 0.061, and 0.034 t/ha per year based on 66 yr data. Yield increases with time were attributed mainly to the introduction of new cultivars. In recent years, barley has outyielded oats and wheat (utility wheat excluded) on a unit-weight basis even though barley yields were the lowest of the three cereals when the rotation began. The relationships between yield and various climatic variables were also studied for each of the three cereal crops. The climatic variables and date of harvest had virtually no effect on yield. Wheat yields were enhanced when seeding took place during the last 13 days of April compared to those when the crop was seeded during the first 13 days of May.

*Salinity of irrigated soil.* Thirteen sites across southern Alberta were selected to study the effects of long-term irrigation on soil salinity. Of the 13 sampling sites, 10 have been under irrigation for more than 50 yr and the others for 26 yr. In 1978, soil samples were taken at regular depth intervals to at least 150 cm. The total soluble salt content of the soil was determined either by evaporating the filtrate to dryness or by measuring electrical conductivity ( $EC_e$ ) of the saturation extract. In general, the total soluble salt

content of the soil in the root zone decreased except at sites in Hays, Tempest, and Lethbridge, where the salt content was essentially unchanged or slightly increased after long-term irrigation. Apparently, irrigation agriculture in this region can be sustained under present management, without soils becoming seriously saline.

*Comparative production of sorghum and barley.* In a 2 yr study at Vauxhall, both sorghum and barley responded to irrigation even when precipitation was relatively high and well distributed. Sorghum required irrigation longer and thus used an average of

25% more water than barley. Both crops also responded to increasing rates of N up to 80 kg/ha but barley made best use of N on dry land. Sorghum required irrigation throughout its extended growing season to effectively utilize increasing rates of N fertilizer. In 1978, barley produced 20% more grain than sorghum; but in 1979, under optimum climatic and agronomic conditions for sorghum, barley and sorghum grain production were equal at 6600 kg/ha. Any varietal improvement or any price or disposal advantage that favors sorghum will provide a further inducement to grow this crop as an alternate to barley.

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# Research Station

## Agassiz, British Columbia

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A. R. MAURER, B.S.A., M.Sc.	Physiology of vegetable crops
P. W. PERRIN, B.Sc., Ph.D.	Postharvest physiology

### Departure

A. T. HILL, B.S.A., M.S.A., Ph.D. Retired 28 December 1979	Poultry management
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<sup>1</sup>Seconded from Libraries Division, Finance and Administration Branch.

<sup>2</sup>Seconded to Sarawak Soil Survey Project, Malaysia, from May 1977 to July 1979.

## INTRODUCTION

The highlight of the year was the establishment of a vegetable storage research program with the appointment of Dr. P. W. Perrin. Dr. D. K. Taylor, who retired in 1978, has continued to carry out research on turf and cereals. We wish to acknowledge the long and dedicated service of Dr. A. T. Hill who retired in 1979.

Giant radish could become an important new vegetable crop. Weather was found to markedly influence the relative sensitivity of potato cultivars to the herbicide metribuzin. Broccoli was successfully grown and harvested from 20 May to 24 December. High levels of phosphorus fertilization hastened maturity and increased grain content of corn silage. Widespread deficiencies of essential plant nutrients were documented in filbert orchards. The potential for rather widespread sulfur deficiencies in the coastal region of British Columbia was indicated by a marked response to sulfur fertilization by pasture grasses.

Candle rapeseed meal was found to be equal to soybean meal for use in a starter ration for calves. Steers fed on pasture produced carcasses with a yellowish fat color which was satisfactorily reduced after 2 mo in the feedlot. Strain of the broilers grown was a more important influence than the feeding regime on the grade of roaster chickens.

The text summarizes highlights of research conducted in 1979. The list of publications provides a more detailed indication of research activities. Requests for information on these and other projects, for reprints or correspondence should be directed to: Research Station, Research Branch, Agriculture Canada, P.O. Box 1000, Agassiz, B.C. V0M 1A0.

J. E. Miltimore  
Director

## ANIMAL SCIENCE

*Use of  $^{65}\text{Cu}$  as a tracer in biological studies.* Preliminary results indicate that  $^{65}\text{Cu}$  (a stable isotope) may be utilized as a tracer in Cu nutrition and metabolism experiments. Preparative and analytical (mass spectrometric) techniques for the analysis of liver, plasma, feces, and milk have been developed and appear acceptable.

*Metabolic indicators of chronic Cu toxicity in sheep.* No effect of Cu supplementation at 16.7, 23.7, and 33.9 ppm in the ration was observed compared to controls at 10.2 and 7.9 ppm for the following parameters: average daily gain, mortality, and blood constituents related to Cu metabolism (superoxide dismutase, catalase, allantoin, red cell volume, hemoglobin, Cu, uric acid, and glutathione peroxidase). Plasma ferroxidase, glutamic oxaloacetic transaminase, and liver copper showed responses to supplemental dietary Cu.

*Processed aspen chips as a forage substitute.* Processed aspen was added at 0, 10, and 20% to corn silage fed to lactating cows. Cows consumed 11.8, 13.4, and 13.4 kg silage dry matter (DM) and produced milk at 25.7, 27.0, and 26.8 kg/day, respectively. Inclusion

of aspen chips did not improve milk fat but did reduce ration digestibility.

*Utilization of milk progesterone for estrus detection.* The mean time of the first progesterone-detected heat occurred at  $34 \pm 11$  days whereas the first visually detected heat occurred at  $50 \pm 27$  days postpartum. Cows that were bred at first observed heat, after 60 days postpartum, conceived at  $89 \pm 34$  days and required 1.6 services per conception, while cows that were first bred after 80 days postpartum conceived at  $119 \pm 47$  days and required 2.0 services per conception.

*Candle rapeseed meal for calves.* Feeding Holstein calves a starter ration containing either Candle rapeseed meal or soybean meal gave equal growth rates, feed intakes, and ration digestibilities.

*Carcass coloration in grass-fed beef cattle.* Hereford steers reared on lush pasture and slaughtered at 400 kg attained an average amber color rating of 6.5 (1 = white, 9 = yellow). A value greater than 5 results in some wholesale buyer resistance. Subsequent heavy grain feeding for 60 days reduced carcass color to below 4.

*Performance of Simmental × Holstein (F<sub>1</sub>) crossbreds.* The growth and carcass characteristics of 42 purebred Holstein-Friesian steers were compared with 64 Simmental × Holstein (F<sub>1</sub>) crossbreds (37 steers and 27 heifers). There were no significant differences in rate of gain or feed efficiency between the two groups of steers, but heifers were less efficient and grew more slowly than both groups of steers. Crossbred heifers had the greatest offal fat and crossbred steers the least, while Holsteins steers were intermediate. Heifers had 67.2%, Holstein steers 70.4%, and crossbred steers 71.8% lean meat in the carcass.

*Layer cage size and orientation.* Birds on low-density feed in traditionally deep cages with a narrow front had depressed egg production while performance in shallow cages with greater front, and therefore greater feed trough space, was excellent. Layers on a higher-density feed in deep and shallow cages had excellent egg production, thus demonstrating that low-density feed is a stress factor in deep cages with limited feeding space.

*Storage life of eggs.* Albumen quality variability was associated with age of layer and, surprisingly, color of shell. Days in storage, and oiling, had little effect. Sample sizes required to estimate the albumen quality of eggs, for brown-shelled eggs, were 19 eggs at 28 wk and 52 at 76 wk of age. For white-shelled eggs comparable sample sizes were 16 and 32 eggs. These results were required in order to date-stamp egg cartons reliably.

*Broiler breeders in cages.* Eggs can be produced satisfactorily by hens in cages, particularly with a small number of birds per cage. Fertility, by natural matings or by artificial insemination, has been unsatisfactory. Until this difficulty has been overcome, the management of broiler breeders in cages will be uneconomical.

*Egg production and energy intakes.* There was no interaction between dietary energy content and the level of restriction on the economic production traits of layers. Energy intake was found to be more important in maintaining egg production than the level of protein intake over the range tested.

*Growth rate influence on roaster product.* A serious problem exists in the high percentage of undergrades in this class of chicken, and it would appear to be related to the stress

imposed by the rapid growth and the physical size of these large birds. Control of growth rate either by reduced dietary protein level or by physical restriction of feed intake did not reduce the percentage of undergrades produced. Strain of broiler stock used to produce this product was found to be important.

## CROP SCIENCE

*Influence of weather on the response of potato cultivars to metribuzin.* The response of 11 potato cultivars to metribuzin was studied over a 5 yr period. The herbicide was applied preemergence, preemergence plus postemergence, and early postemergence. The response to metribuzin was influenced by weather conditions. Postemergence sprays applied at temperatures over 21°C resulted in increased top growth injury which was reflected in decreased yields. Cultivars showing sensitivity to metribuzin at these temperatures included Belleisle, Early Rose, Kennebec, Netted Gem, Red La Soda, Red Pontiac, and White Rose. Cultivars responded to the amount of sunshine before, during, and after spraying. When weather conditions were cloudy before and during spraying, then changing to sunshine after spraying, cultivars Belleisle, Netted Gem, and Warba were injured. Cultivars showing sensitivity under stress (lack of water) were Belleisle, Epicure, Norland, Red Pontiac, and White Rose. Wet soil increased sensitivity of Epicure, Netted Gem, Norgold Russet, and Warba to preemergence applications.

*Quackgrass control in raspberries.* Several herbicide treatments were tested for quackgrass (*Agropyron repens* (L.) Beauv.) control in raspberries over a 4 yr period. Both glyphosate and pronamide gave good quackgrass control. Glyphosate appeared more effective when applied in late fall while pronamide appeared more effective when applied in early spring. The addition of simazine to glyphosate caused little or no improvement in grass control. A paraquat-simazine mixture did not give satisfactory grass control. Pronamide applied either in the fall or spring caused a reduction in the new cane growth, with 3.36 kg/ha in the spring causing a significant reduction in the number of raspberry sucker plants. Grass competition in the unweeded check plots reduced the number of canes and yield of berries. The

crop was not affected adversely by the herbicide treatments. The pronamide-treated plants tended to give the highest yields.

*Planting time for forage corn.* Planting in late April compared to late May increased total forage and grain yield by 6 and 37%, respectively, and resulted in forage containing 10% more grain at harvest. Early planting also increased forage DM content at harvest by 4.8%.

*Phosphorus fertilizer for corn.* On a soil with a high level of available P, corn responded similarly to P fertilizer regardless of whether it was broadcast and incorporated or banded at seeding. However, high rates of P ( $P_2O_5$  up to 160 kg/ha) increased early plant vigor, advanced flowering by 2 days, and increased forage and grain DM contents at harvest by 1.7 and 3.6%, respectively.

*Corn hybrid maturity assessment.* Over three locations, the corn heat unit system for rating hybrids was more reliable for assessing grain percentage dry matter (DM) ( $r$  of  $-0.80$  to  $-0.83$ ) than forage percentage DM ( $r$  of  $-0.62$  to  $-0.69$ ). Forage DM content at harvest was dependent on the DM content of the stover and the proportion of total DM as grain or in the ear.

*Perennial ryegrasses.* In the 1st yr of production, diploid varieties were 12% more productive than tetraploid varieties when mechanically grazed (eight cuts, N at 450 kg/ha) but both types were equally productive when grown for conservation as hay or silage (four cuts, N at 300 kg/ha).

*Fertilizer requirements of filberts as reflected by leaf analysis.* Chemical analysis data obtained from a leaf tissue survey of

filbert orchards in British Columbia when compared to literature values indicated a high deficiency of potassium and also some deficiencies of nitrogen, phosphorus, calcium, magnesium, and boron. Instances of excesses of nitrogen, phosphorus, and potassium were also found.

*Evidence of sulfur and nitrogen deficiency in a coastal soil.* In a field fertilizer trial with forage grass, dry matter yields were doubled by a combination of nitrogen and sulfur fertilizer application. Without sulfur, the forage grass did not respond to nitrogen.

*New and exotic vegetables.* Screening trials revealed that amongst giant radish cultivars, one hybrid from Korea was outstanding in quality, yield, and resistance to bolting. One Florence fennel cultivar from France produced excellent bulbs of high culinary quality. Precision seeding of Belgian endive (witloof) produced more uniform roots than scatter-shoe planting. Time of planting and harvest was critical for production of easily forced roots. Overwintered onions, cauliflower, carrots, and Swiss chicory survived the 1979–1980 winter. New crops, which did not perform satisfactorily or which had limited culinary appeal, include edible burdock, cardoon, okra, scorzonera, salsify, Japanese garland, and cicora Catalogna.

*Broccoli season extension.* Nine trials were run at 3 wk intervals to assess the performance of six cultivars. Harvesting began on 20 May and continued until 24 December. Yields were least in December. Quality was affected by “rain rot” in the third planting and heat stress in the fourth. The cultivar Premium Crop, followed by Green Duke, had the best overall performances. Corvet was satisfactory during cool weather only.

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# Research Station

## Kamloops, British Columbia

### PROFESSIONAL STAFF

A. McLEAN, B.S.A., M.Sc., Ph.D.	Acting Director; Range ecology
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<sup>1</sup>Appointed April 1979.

<sup>2</sup>Transferred from Kamloops, October 1979.

## INTRODUCTION

Forage crops and beef cattle research programs are under way at the Kamloops Research Station. Administration of the Prince George Experimental Farm was transferred to the Kamloops Research Station from the Beaverlodge Research Station in Alberta on 1 April 1979.

In April W. L. Pringle, a forage crops specialist with many years of experience in the north, was appointed Superintendent of the Prince George Experimental Farm, and in October K. Broersma, a soils agronomist with experience in forage crop production, was transferred from Kamloops to Prince George. The offices of the British Columbia Ministry of Agriculture are located on the Experimental Farm at Prince George. This association has resulted in excellent communication and cooperation between the two agencies, benefiting agriculture in the region.

This Experimental Farm has responsibility for the region from Hazelton to McBride and south to Quesnel. The region is suited to growing cultivated forage crops and beef production. The research program objective of this Experimental Farm is to solve production and utilization problems of forage crops. Emphasis is given to evaluation of grass and legume cultivars as related to climate and soil fertility and to evaluation of cereal versus grass-legume silage when fed to wintering beef cattle.

We place great importance on research at Prince George and believe this research can make a significant impact on the agricultural industry of the region.

The administration of the Creston Substation was placed under the Summerland Research Station in October. Kamloops will, however, maintain forage crops research in the Creston area.

Further information on this research may be obtained by writing to the Director, Agriculture Canada, Research Station, 3015 Ord Road, Kamloops, B.C. V2B 8A9, and that of the Experimental Farm by writing to the Superintendent, Agriculture Canada, Experimental Farm, RR#1, Prince George, B.C. V2N 2H8.

A. McLean  
Acting Director

### PLANT BIOCHEMISTRY

#### Alkaloids in reed canarygrass

The alkaloids of reed canarygrass, *Phalaris arundinacea* L., respond to changes in soil moisture and nitrogen fertility. Gramine and hordenine levels increased under field conditions of moisture deprivation. This effect was enhanced when nitrogen fertilizer was applied. The level of 5-methoxy-*N*-methyltryptamine was affected mainly by the nitrogen amendment. Exceptional alkaloid levels in reed canarygrass can be predicted in relation to climatic and plant osmotic parameters. Improved fluorescence scanning procedures were developed for thin-layer chromatography (TLC) quantifying reed canarygrass alkaloids.

#### Saskatoon serviceberry poisons cattle

Twigs of Saskatoon serviceberry, *Amelanchier alnifolia* Nutt., were administered to cattle in feed rations and by intraruminal dosing to determine the toxicity of the cyanogenic shrub. When chopped twigs were fed as 75% of the diet, cattle exhibited restlessness, shivering, loss of weight, scours, and shortness of breath. Low-level dosing experiments indicated a rapid turnover of hydrogen cyanide (HCN) in the rumen. When potential doses of HCN were increased to 5 mg/kg (body weight) progressive stages of poisoning developed rapidly, rumen HCN levels were elevated for at least 3 h, and the increase in heart rate correlated with the rise in blood HCN concentration.

## Toxicity of timber milk-vetch to honey bees

Field observations over a period of 3 yr linked the occurrence of honey bee poisoning to timber milk-vetch, *Astragalus miser* Dougl. ex Hook., in flower. The nectar of this plant was found to contain miserotoxin, a nitropropanol glycoside. Feeding trials with caged bees demonstrated the toxicity of aliphatic nitro compounds. TLC methods were developed for detecting nitrotoxins in nectar and the rectal sacs of honey bees.

## RANGE MANAGEMENT

### Feeding habits of cattle and mule deer on winter range

Studies on the winter range have been completed and have resulted in recommendations for improved grazing management planning which should keep conflicts to a minimum. Interaction between mule deer, *Odocoileus hemionus hemionus*, and cattle took various forms. The potential for direct competition was greatest in spring. Both deer and cattle selected bluebunch wheatgrass, *Agropyron spicatum* (Pursh) Scribn. & Smith, and crested wheatgrass, *Agropyron desertorum* (Fisch.) Schult., while Sandberg bluegrass, *Poa sandbergii* Vasey, was most often eaten by deer. Evidence of indirect interaction was observed. Moderate or heavy fall grazing by cattle made the spring forage more attractive to deer by removing mature forage.

## WEED CONTROL

### Ecology of knapweed

Plants of diffuse knapweed, *Centaurea diffusa* Lam., have survived for 4 yr without bolting, indicating that the species can be more than a short-lived perennial.

Extracts of diffuse and spotted knapweed, *C. maculosa* Lam., inhibited germination and growth of alfalfa, crested wheatgrass, barley, and annual ryegrass. The allelopathic potential appears to vary between seasons among sites, and bioassays indicated that different species were affected in varying degrees. Soils from knapweed-infested areas also yielded inhibitory extracts.

## RANGE IMPROVEMENT

### Range seeder modified

The 3.7 m rangeland seeder constructed in cooperation with the Agricultural Engineering Branch, British Columbia Ministry of Agriculture, has proved to be very successful. Since the start of the seeding 4 yr ago, about 5670 ha have been seeded. Seeding was at least a partial success on all sites. In 1978, a 2.7 m model was constructed that was easier to move on the highway and easier for a rancher to use on his own. During the 1979 season we found that the smaller machine took almost as much power to pull as the large model. The machine handles well on rough rocky ground, since the discs maintain maximum contact with the soil. It also chops 1 m tall shrubs without having the debris pile up. Sometimes double discing is necessary in heavy sod. Seeding depth control has been good. Loose soil does not pile up in front of the large rollers.

## SOILS

### Irrigation of pulp mill effluent

In response to a proposal from the Kamloops Pulp Mill of Weyerhaeuser Canada Ltd. to investigate the feasibility of using the mill's effluent for irrigation water as a means of its disposal, a preliminary trial was conducted on a fairway of the Kamloops golf course for one growing season. Analyses of the effluent waters indicated medium to high salinity (1.7–2.0 mS/cm) and low to medium sodium hazard (sodium absorption rates 7.4–8.7).

Soil reaction, salinity, and exchangeable sodium percentage (ESP) were increased significantly after 3 mo of flood irrigation with effluent at the rate of 5 cm/wk, as compared to that of normal river water. ESP increased from 0.7 to 18.3 for the 0–14 cm soil layer and from 1.8 to 9.1 for the 14–25 cm. Slightly larger increases were noted for an effluent irrigation regime of 8 cm/wk. These increases approach the "critical" ESP value of 15 for the surface 25 cm, although no visible deterioration of soil structure or permeability was noted during the short term of the trial.

During the 2 mo period following the trial, normal sprinkler irrigation was applied and 4 cm of precipitation fell on the trial area. ESP of plots receiving effluent at 5 cm/wk had changed from 18.3 to 8.8 for the 0–14 cm

layer, 9.1 to 10.1 for the 14–25 cm layer, and from 3.4 to 5.7 for the 25–50 cm layer during this period. This indicates considerable improvement in soil quality of surface layer due to the leaching effect of the better-quality water.

The trial indicates that soil salinity increases could be controlled by applying water

in excess of evapotranspiration needs. Soil permeability problems, however, could develop due to exchangeable sodium buildup. Periodic soil analyses would be necessary to assess this sodium hazard so that corrective measures, such as gypsum application, could be taken before serious problems developed.

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# Saanichton Research Station

## Sidney, British Columbia

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#### Administration

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R. G. ATKINSON, B.S.A., Ph.D.	Plant pathology
A. W. CHIKO, B.Sc., M.S., Ph.D.	Viruses—Ornamentals
R. E. HARRIS, B.S.A., M.S.A., Ph.D.	Plant physiology—Tissue culture
W. C. LIN, B.S., M.Sc., Ph.D.	Plant physiology—Ornamentals
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VACANT	Vegetable physiology
C. M. WINTER, <sup>2</sup> B.S.A.	Acting Officer in Charge, Post Entry Quarantine Station

#### Departure

D. R. BERTOIA, <sup>2</sup> B.S.A.	Officer in Charge, Post Entry Quarantine Station
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D. P. ELLIOTT,<sup>3</sup> B.Ed.

Greenhouse and vegetable crops  
Greenhouse biological control

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## INTRODUCTION

The Saanichton Research Station is the ornamental and greenhouse vegetable center for British Columbia, and most of the Station's programs are oriented to solving problems and giving direct service to the ornamentals and vegetable industry.

Emphasis in research is being given to nutritional and physiological problems in floriculture; plant propagation, postrooting development, and long-distance shipping of plants for the nursery industry; the eradication of viruses and rapid multiplication of grapes and ornamentals by tissue culture; and the control of pests and diseases in vegetables and ornamentals.

The Post Entry Quarantine Station, a joint venture between the Food Production and Inspection Branch and the Research Branch, made a significant contribution to Canadian agriculture.

Requests for information or publications should be addressed to the Saanichton Research Station, Agriculture Canada, 8801 East Saanich Road, Sidney, B.C. V8L 1H3.

J. M. Molnar  
Director

## ORNAMENTALS

*Alstroemeria*. Daily 16 h supplementary lighting with high-pressure sodium (HPS) lamps increased the number of flower shoots per square metre per year from 545 to 755 for cv. Orchid and from 387 to 454 for Regina and promoted early flowering in the spring. Under HPS, the number of flower shoots per square metre per year varied between cultivars: Orchid produced 755; Orange Beauty, 715; Regina, 454; Canaria, 443; Beauty, 267; and Red Surprise, 247.

*Gerbera*. Heating the soil to 24°C and providing 16 h supplementary lighting with HPS lamps increased the number of flowers per plant, improved growth, and reduced *Phytophthora* infection. The number of flowers per square metre per year in pots was 247 as compared to 223 in beds with areas of disease and 291 in clean beds.

*Geranium*. Seed geraniums (*Pelargonium hortorum*) with one application of Cycocel flowered 3–14 days earlier than the controls. Supplementary lighting with HPS lamps during the first 8 wk of the growing season resulted in 7–18 days earlier flowering. Lighting for the first 8 wk was as effective as lighting during the whole growing season of 16 wk.

*Poinsettia*. Combinations of ammonium and nitrate resulted in better growth and quality of pot poinsettias (*Euphorbia pulcherrima*) than either nitrogen source alone.

Ammonium-treated plants developed severe necrosis on lower leaves following the application of nitrate in the middle of the growing season. The severity of the symptom increased from soil-peat-perlite, to peat-vermiculite, and to peat-sawdust.

*Carbonated mist propagation*. The injection of CO<sub>2</sub> into mist water increased percent rooting of English holly, *Rhododendron* spp., *Chamaecyparis* spp., *Juniperus* spp., and Douglas fir and increased the number, length, and fresh weight of roots per cutting, especially with *Taxus media* and *Pseudotsuga menziesii* '162'. Both CO<sub>2</sub> mist and 16 h HPS lighting increased percent rooting and the number and length of roots per cutting of *Magnolia* spp.

*Accelerated growth of ornamental plants*. Daily 16 h supplementary lighting with HPS or low-pressure sodium (LPS) lamps accelerated growth of English holly, white spruce, Douglas fir, Canada hemlock, and crape myrtle. HPS and LPS were equally effective in promoting growth. Carbon dioxide at 1000–1300 ppm with or without lighting increased the growth of English holly during October and November 1979, but had no effect on other plant species. The increased growth of Japanese holly, Japanese aucuba, and *Viburnum* sp. under HPS or LPS required higher fertilizing than nonlighted plants.

*Control of black vine weevil.* Soluble powder acephate and emulsifiable concentrates of acephate, permethrin, diazinon, malathion, fenvalerate, and Ripcord applied as soil drenches to container-grown *Rhododendron* and azalea reduced root weevil larval populations significantly, but acephate emulsifiable was phytotoxic. Potassium oleate drenches at concentrations up to 5.0% were not effective for control of root weevils on azalea. Diflubenzuron soil drenches with active ingredient at 0.25 g/L gave good control of root weevils, but lower rates were ineffective. Adult black vine weevils fed on diflubenzuron-treated foliage showed no differences in total egg production or viability compared to untreated adults. Previous trials with oxamyl foliar sprays indicated promising control of root weevil larvae, but trials this year failed to indicate any significant control.

*Winter moth control of apple.* Sprays of acephate, carbaryl, lindane, methoxychlor, and permethrin applied at three rates to apple tree trunks in November and December did not provide adequate control of adult females. Spring foliar sprays with methoxychlor at 0.1% and 0.05% gave excellent larvae control, but methoxychlor at 0.01% and potassium oleate at 1.0% and 0.5% were not effective. Control with methoxychlor at 0.01% was enhanced with the addition of potassium oleate at 1.0%.

*Phytophthora root rot of ornamentals.* No resistance to *Phytophthora* root rot was found in seedlings of *Chamaecyparis lawsoniana* vars. *allumii*, *erecta*, *gracilis*, *schongariensis*, and *westermanii* when grown in soil infested with *P. cinnamomi*. However, *Cupressocyparis leylandii* (*Chamaecyparis nootkatensis* × *Cupressus macrocarpa*), widely used for hedge plantings, proved to be resistant. Neither "composted" nor "noncomposted" fir-bark prevented *Phytophthora* root rot of Lawson cypress when used in bark:soil ratios of 1:1 and 2:1.

## SMALL FRUITS

*Eradication of virus in grapes.* In vitro culture of shoot-tips eradicated fanleaf from Forta and Auxerrois (Cl. 21) without heat treatment and leafroll from Liemberger after 3 mo heat treatment of the infected plant at 38°C. New procedures developed this year

were used to root all 21 accessions cultured from heat-treated tips.

*Rapid propagation of virus-free grapes.* Murashige's minimal organic medium with adenine sulfate at 80 mg/L,  $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$  at 170 mg/L, and benzylaminopurine at 2-4 mg/L produced the optimum number of shoots in 80-90% of all genotypes tested. From 60 to 100% of the proliferated shoots root in 8-21 days.

*Rapid propagation of the Saskatoon (Ame-lanchier alnifolia).* The Saskatoon cv. Smoky proliferates readily in Murashige's minimal organic medium with benzylaminopurine at 2-4 mg/L, but rooting of the proliferated shoots is variable. Rooted explants usually go dormant soon after rooting. Rooting is considerably better on bridges in liquid than on agar media.

## VEGETABLES

*Speedling trays (72 cavity) versus 10 cm pots for growing Vendor tomato plants.* The early and total yields and size of fruit were higher from plants grown in speedling trays than from 10 cm pots if the plants were transplanted at the four- or five-leaf stage. With older plants, yields from the speedling grown plants were generally lower than from the 10 cm pots, but the percentage of large fruit remained higher.

*Micronutrient concentration for long English cucumbers grown in sawdust.* Long English cucumbers were supplied with standard macronutrients with a micronutrient mix (Plant-Gro) at 3, 11, 22, or 33 mg/L. None of the micronutrient concentrations affected plant growth or fruit yield, and no deficiency or toxicity symptoms were evident. However, with micronutrients supplied at 11, 22, and 33 mg/L, the Bo in the leaves exceeded the recommended level, and at 22 and 33 mg/L the Mn in the leaves also exceeded the recommended level.

*Comparison of various micronutrient mixes for growing long English cucumbers in sawdust.* The micronutrient mixes Plant Prod. (21 mg/L), Green Valley (20 mg/L), 1/2-Saanichton plus borate (8 and 0.3 mg/L, respectively), and fritted trace elements (Pre-Mix) mixed with sawdust at 88 g/m<sup>3</sup> did not have any effect on yield, but plant growth and appearance seemed to be better with the

Green Valley and 1/2-Saanichton plus borate mixes.

Leaf analysis indicated a satisfactory Fe level in all mixes; high Mn and Bo in all mixes except Pre-Mix; and high Zn in the 1/2-Saanichton and Pre-Mix treatments.

*Greenhouse tomato variety trials.* Twenty-seven cultivars and hybrids were compared at both the Research Station and a commercial grower's greenhouse. Most of these produced higher yields and smaller fruit than Vendor but required more labor. Rianto, Quanto, Hg77-455, and a selection of Vendor were the most promising.

*Supplemental lighting for growing tomato seedlings.* HPS lights for 16 and 24 h/day increased the rate of growth, reduced the time from seedling to transplanting by 3 wk, and increased the number of fruit, total and early yield. However, the supplemental lighting reduced fruit size and percentage of large fruits, especially with 24 h light.

*Plastic tunnels and mulches.* Tomato cv. Sub-Arctic Maxi and Fireball transplanted in double-plastic tunnels on 3 March survived -4°C but plants in all other treatments were killed. Planting in double-plastic tunnels advanced earliness of ripening but produced a lower yield (3.1 kg per plant) than plants transplanted to clear plastic mulches on 4 April (4.2 kg).

*Biological control program for whitefly and mite control on greenhouse vegetables.* In 1979, 75% of commercial greenhouse cucumber growers and 38% of the tomato growers in British Columbia participated in a cooperative program of the British Columbia Ministry of Agriculture and Agriculture Canada to supply whitefly parasites and mite predators. Pesticide use was reduced and control was

satisfactory in most houses. This program is continuing under an Agriculture and Rural Development Subsidiary Agreement grant.

*Black rot of cucumbers.* The long English cucumber varieties Princess, Greenspot, Femdan, Monique, and Sporu were rated only moderately susceptible, while Uniflora, La Reine, Boneva, Virgo A, Pepinex, and Femspot were rated very susceptible to black rot when grown in soil infested with *Phomopsis cucurbitae*. Burpee Hybrid was the only variety tested that remained healthy. All varieties were, however, equally susceptible to rotting of the fruit when inoculated with the black rot *Phomopsis*.

## POST ENTRY QUARANTINE STATION

In 1979, 45 tree fruits, 85 grapevines, and 76 audit samples were received from foreign and domestic sources for indexing. In total, 50% of the uncertified tree fruits and grape plants received from all sources were infected.

One hundred tree fruit accessions, of which 63 were heat-treated, and 32 grapevines, of which 10 were heat-treated, were indexed and released. The two most notable grape varieties released were Liemberger and Miczurinoweic. Most of the releases will be included in the National Repository. The grape virus "Fleck" has been dropped from the list of Canadian quarantinable viruses, thus releasing more varieties for distribution. The repository now contains a total of 558 tree fruits and 249 grape cultivars. In 1979, 46 020 tree fruit and 7500 grape buds were distributed.

With the assistance of the Vineland Research Station, the enzyme-labeled immunosorbent assay (ELISA) method has been expanded for arabis mosiac, fanleaf, tomato ringspot, and tobacco ringspot.

## PUBLICATIONS

### Research

Nil

### Miscellaneous

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Lin, W. C. 1979. Nitrogen sources and growing media for pot poinsettias. HortScience 14(3):453 (Abstract).

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- Molnar, J. M. 1979. Ornamentals research update. *Landscape Alta.* 2(4):2-3, 16-17.
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- Molnar, J. M. 1979. An integrated system (lighting, CO<sub>2</sub> and temperature) for rooting cuttings and growing liners. *Ornamentals Northwest* 3(3):6 (Abstract).
- Nielson, D.; Tonks, N. V. 1979. Insecticides—What's registered and effective and/or new (to include those registered for greenhouse as well as field application). *Ornamentals Northwest* 3(3):19 (Abstract).
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# Research Station

## Summerland, British Columbia

### PROFESSIONAL STAFF

G. C. RUSSELL, B.S., M.S., Ph.D.	Director
H. F. MADSEN, B.A., Ph.D.	Associate Director
L. C. GODFREY, B.Sc.	Head, Administration
V. B. SMITH, <sup>1</sup> B.A., M.L.S.	Librarian

### Entomology

R. D. McMULLEN, B.Sc., M.Sc., Ph.D.	Head of Section; Bionomics of pear psylla
F. L. BANHAM, B.A.	Stone fruit insects
R. S. DOWNING, B.A., M.S.	Orchard mite control
A. P. GAUNCE, B.Sc., M.Sc., Ph.D.	Pesticide and environmental chemistry
H. F. MADSEN, B.A., Ph.D.	Integrated control
M. D. PROVERBS, B.Sc., M.Sc., Ph.D.	Control of codling moth by the sterility method

### Food Processing

J. A. KITSON, B.A., M.S.	Head of Section; Engineering new products
D. BRITTON, Dip. H.Ec.	Home Economist
H. A. BUTTKUS, B.S.A., M.A.	Food biochemistry
D. R. MACGREGOR, B.S.A., M.S., Ph.D.	Product development and microbiology
G. E. STRACHAN, B.S.A., M.Sc., Ph.D.	Enology and food technology

### Plant Pathology

VACANT	Head of Section; Tree fruit fungus diseases
A. J. HANSEN, Dip. Agr., M.Sc., Ph.D.	Tree fruit virus diseases
W. J. MCPHEE, B.A., M.Sc., Ph.D.	Tree fruit fungus diseases

### Pomology and Viticulture

N. E. LOONEY, B.S., M.S., Ph.D.	Head of Section; Growth regulants and agrometeorology
L. G. DENBY, B.S.A., M.S.A., F.R.H.S.	Rootstock and variety evaluation—grape breeding
W. D. LANE, B.Sc. (Agr.), M.Sc., Ph.D.	Fruit breeding—hardiness
M. MEHERIUK, B.Sc., B.Ed., M.Sc., Ph.D.	Fruit biochemistry
S. W. PORRITT, B.S.A., M.S., Ph.D.	Fruit storage

### Soil Science and Agricultural Engineering

D. S. STEVENSON, B.S.A., M.S., Ph.D.	Head of Section; Soil moisture
E. J. HOGUE, B.S.A., M.S., Ph.D.	Vegetation management
P. B. HOYT, B.Sc., M.S., Ph.D.	Soil chemistry
A. L. MOYLS, B.A.Sc., M.S., Ph.D.	Agricultural equipment—development and assessment
G. H. NEILSEN, B.Sc., M.Sc., Ph.D.	Soil fertility and plant nutrition
P. PARCHOMCHUK, <sup>2</sup> B.A.Sc., M.S.	Agricultural equipment—development and assessment

### Departures

D. BRITTON Retired December 1979	Home Economist
R. S. DOWNING Retired December 1979	Orchard mite control
S. W. PORRITT Retired December 1979	Fruit storage

## VISITING SCIENTISTS

W. A. LAMPMAN,<sup>3</sup> B.A.Sc., M.S.

Food processing

O. LAU,<sup>4</sup> B.S., M.S., Ph.D.

Pomology

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Pomology

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<sup>1</sup>Seconded from Libraries Division, Finance and Administration Branch.

<sup>2</sup>On CIDA assignment from October 1979 to October 1981.

<sup>3</sup>On work transfer from University of Saskatchewan, Agricultural Engineering Department, from 15 July 1979 to 20 November 1979.

<sup>4</sup>B.C. Tree Fruits Research Associate since July 1976.

<sup>5</sup>On work transfer from Njøs Agriculture Research Station in Western Norway from November 1979 to February 1980.

## INTRODUCTION

The research programs at the Research Station, Summerland, are concerned with all aspects of production, protection, and utilization of tree fruits and grapes. In addition to the facilities at Summerland, substations are located at Kelowna and Creston, and numerous sites on the properties of private cooperators are utilized to conduct research in pomology, agricultural engineering, soils and irrigation, plant pathology, and entomology. Research into processing and storage of products is also a major function of the Station.

This report contains a few highlights of the research during 1979 to show the fields of endeavor and the type of experiments being conducted. More detailed information on any of the projects and reprints of published papers are available on request from Agriculture Canada, Research Station, Summerland, B.C. V0H 1Z0.

G. C. Russell  
Director

## ENTOMOLOGY

### **Codling moth behavior affected by temperature regimen during rearing**

The effectiveness of the sterility principle of insect control is largely influenced by the dispersal rate of the released insects. During cool spring weather, male codling moths laboratory-reared at a constant high temperature (27°C) disperse very slowly when released in orchards and respond poorly to sexually receptive females. It was found, however, that dispersal and sexual response were appreciably improved during cool weather by rearing the insects at fluctuating temperatures (16–27 or 21–32°C). During hot weather, flight and sexual behavior were unaffected by the temperature regimen during rearing. Although male moths mated about as often, they transferred somewhat fewer eupyrene sperm bundles during copulation than males that were reared at a constant high temperature. This may be detrimental since preliminary tests at 27°C indicated that the addition of radiosterile moths to a fertile population was somewhat less effective in suppressing reproduction if the sterilized insects were from a fluctuating temperature colony than if they originated from a constant temperature colony.

### **Fumigation of codling moth on harvested fruit**

The relative resistance of the developmental stages of codling moth to the fumigant methyl bromide was determined. In order of increasing resistance this was adult, larva, egg, and pupa. There were no significant

differences in resistance among the five larval instars, but 1 day old eggs were more resistant than 5 day old eggs and 3 to 8 day old pupae were more resistant than 9 day old pupae. In a large-scale trial, more than 30 000 larvae in cherry fruits and more than 50 000 1 to 2 day old eggs on cherry fruits were fumigated in three replicated lots. The fumigant dose rate was 32 g/m<sup>3</sup> for 2 h. The mean fruit temperatures in the lots with larvae were 19.5, 23.2, and 24.2°C and in the lots with eggs 22.2, 23.9, and 24.0°C. There were no survivors.

### **Sex pheromone traps for leafrollers attacking apples**

The sex pheromones of four leafroller species were evaluated in orchards. Male fruittree leafroller, European leafroller, and threelined leafroller moths were attracted to their specific pheromones, but male oblique-banded leafroller moths were attracted both to their own pheromone and to the pheromone of the European leafroller. Sex pheromone traps were found useful to identify the leafroller species in orchards and to time application of summer sprays for the control of the multiple-generation obliquebanded and threelined leafrollers. They are potentially useful to monitor leafroller populations in pest-managed orchards to determine if chemical controls are needed.

### **Control of leafrollers with environmentally safe pesticides**

*Bacillus thuringiensis*, diflubenzuron, and insecticidal soap, alone and in combination, were evaluated as pink and petal fall sprays for control of the fruittree leafroller and the



European leafroller. *B. thuringiensis* gave 85–90% mortality of larvae and prevented fruit damage. Diflubenzuron and insecticidal soap were ineffective and fruit damage was the same as in the nonsprayed control. Combinations of these materials did not improve control. Sprays applied at petal fall gave better control than sprays applied at the pink bud stage. *B. thuringiensis* would be a useful material for leafroller control because it does not affect pollinating insects, predators, or parasites. It is also safe to use on the Golden Delicious cultivar which is sensitive to the organophosphate pesticides presently recommended for leafroller control.

### **Control of European fruit scale and San Jose scale**

In 1978, a single spray of diazinon, applied at the pink bud stage when male European fruit scales were starting to emerge, was as effective in controlling the scale as an oil spray at the mouse-ear bud stage. In 1979, two sprays of diazinon, one at the pink bud stage and the other at petal fall, spanned the period of male scale emergence better and gave more effective control than an oil spray applied at the mouse-ear bud stage. Two sprays of diazinon applied in July when European fruit scale crawlers were emerging also gave good control. Supracide (methidathion) applied at the mouse-ear bud stage gave excellent control of San Jose scale and was more effective than oil applied at the same period.

### **Effects of fungicides on a phytoseiid mite predator**

In an apple orchard, sprays of Morestan (chinomethionate) were toxic to the mite predator *Typhlodromus occidentalis*, whereas Bloc (fenarimol), Easout (thiophanate), and wettable sulfur were low in toxicity.

### **Green peach aphid control on peach**

Organochlorine–organophosphate resistant strains of the green peach aphid were effectively controlled by one pink bud stage spray of pirimicarb 50 WP at an active ingredient rate of 500 g/ha. Pirimicarb did not give control of the peach twig borer when applied in summer cover sprays.

### **Little cherry disease vector research**

Since work on this project was started in 1974, a total of 47 species of insects and mites have been tested for ability to transmit little cherry disease. To date, 80 out of 241 tests with the apple mealybug and two out of 58 tests with the plum rust mite have resulted in the expression of early-senescence red-leaf symptoms on Sam variety test trees, indicative of transmission of little cherry disease. In addition, two out of 747 noninoculated control trees expressed similar symptoms. In 1977 and 1978, bud grafts from 10 of the positive mealybug-tested trees, the two positive plum rust mite-tested trees, and the two positive noninoculated trees were placed on mature fruiting cherry trees. The summer following placement of the grafts, seven out of the 10 trees with grafts from the mealybug-tested trees expressed fruit symptoms characteristic of little cherry disease. The other seven grafts did not result in fruit symptoms. It is concluded that the apple mealybug is the vector of little cherry disease in the Okanagan Valley of British Columbia.

### **Insect and mite control on grapes**

The grape erineum mite on Riesling grapes was effectively controlled by a dormant or a late dormant (prior to the wooly bud stage) spray of liquid lime sulfur, 22.5 L/ha.

First- and second-generation Virginia-creeper leafhopper nymphs were effectively controlled by sprays of carbaryl 50 WP applied at an active ingredient rate of 0.28 kg/ha when over 80% of the leafhopper eggs hatched. This timing of the treatments did not significantly reduce parasitism of the leafhopper eggs by the endemic Mymarid parasite, *Anagrus epos*.

## **FOOD PROCESSING**

### **Extrusion forming of dehydrated fruit snacks**

Dehydrated fruit snacks may be prepared from a mixture of low-moisture fruit sauce flakes and fruit juice concentrate. The forming of bars from flake plus concentrate mixtures has been mechanized by development of an inexpensive continuous extruder. In the extruder a meat grinder auger is used as a feed screw to force the product through a single rectangular nozzle. This nozzle is steam jacketed to heat the product slightly and

produce smooth-surfaced bars. The resulting continuous extrusion is cut into bars of the length and weight desired.

### **Mushroom processing**

A lucrative export market exists for wild mushrooms from British Columbia. The pine mushroom (*Armillaria ponderosa*) is highly prized in Japan and a considerable tonnage is exported from the province. The chanterelle (*Cantharellus cibarius*) has a ready market in Europe. There is a possibility of processing these mushrooms for export. Formulations and processes have been developed for canned pine mushrooms in brine and sauce and for canned chanterelle. In addition, freeze-drying and rehydration techniques for pine mushrooms have been elaborated. Pine mushrooms preserved in 24% salt brine can also be successfully desalted and processed.

### **Synthetic sweeteners for low-calorie fruit spreads**

Storage tests on aspartylphenylalanine (Aspartame) in low-calorie fruit spreads were continued to 38 wk. At a level of 0.2% added Aspartame (approximately equivalent in sweetness to 40% sugar) no residual sweetening effect remained after storage at 38°C. At other temperatures sweetness from Aspartame dropped rapidly during preparation followed by a gradual decline in storage, with the rate of decline being lower at lower temperatures. It would probably be economically feasible to manufacture Aspartame-containing low-calorie fruit spreads if a practical means were found to avoid Aspartame losses due to heating in preparation. It would also be necessary to cool products after manufacture.

### **Dehydrated compressed rations**

Storage trials of 1 yr show that dehydrated compressed meat and biscuit bars packed in vacuum in foil laminate pouches retain full acceptability after 1 yr at room temperature. At 38°C meat bars have a distinct overcooked odor and flavor. Biscuit bars suffer some loss of flavor but are still acceptable after 17 months at 38°C.

### **Effluent recirculation blancher**

A COPI contract to construct and test a 1 t/h unit has been let and considerable design work has been done with the contractor. Completion date is aimed for 31 March 1980

and it will be tested in the 1980 season. This steam-generating unit should be compatible with the improved K-1 blancher designed in Kentville. The combination of the K-1 blancher with effluent recirculation would provide the most energy-efficient blanching system presently available.

### **Little cherry (LC)—nucleic acid analysis**

Work to develop a chemical test for the detection of LC virus infected trees was continued. Purification to make leaf tissue extracts suitable for gel electrophoresis was achieved by partitioning the polysaccharides between methoxyethanol and high ionic strength phosphate buffer. When subjected to electrophoresis on 5% polyacrylamide, extracts from control trees did not show the characteristic pink RNA bands on top of the gels nor did they contain the centrally located faint bands. Although the technique involved time-consuming dialysis and freeze-drying steps, the location of the RNA bands, as well as the rate of destaining, permitted differentiation between LC infected and healthy tissue. Extracts of fruit buds also gave characteristic electrophoretograms of LC infected tissue and may thus provide year-round samples for testing of diseased trees.

### **Winemaking trials with wine grapes grown in CDA and BCMA test plots**

Twenty-four of 89 grape cultivars were dropped from testing following the severely cold winter of 1978–1979. Following a June 1979 wine industry workshop, revised evaluation standards were prepared to fulfill the needs of industry. Weather during the autumn of 1979 was near optimum for the development of grapes. Sixty-six varieties have been analyzed and used for wine-making trials from the 1979 harvest.

### **Inhibition of secondary fermentation of wines by potassium sorbate**

Work continued during 1979 on the determination of conditions necessary for the stabilization of wines stored in flexible, oxygen-permeable packages. Strains of yeast were isolated from nine wineries in Ontario and British Columbia in order to assess the sorbate resistance of naturally occurring strains. The most resistant strain was resistant to 1000 ppm sorbic acid when grown in a standard yeast medium at neutral pH. In wine

500 ppm was sufficient to inhibit all strains tested.

## PLANT PATHOLOGY

### Evaluation of new fungicides for disease control

Only two of 24 chemicals screened were found promising for the control of "bunch rot" caused by *Botrytis cinerea* on grapes, and two for control of powdery mildew caused by *Podosphaera leucotricha* on apples. In packinghouse trials, Rovral was effective for controlling green mold caused by *Alternaria* spp. on cherries.

### Postharvest disorders

A rot of apples and pears at first attributed to *Corticium centrifugum* has been increasing in frequency over the past 5 yr and now appears to be a serious problem to the industry. Recent studies show that the causal organism is a low temperature basidiomycete with an optimum growth temperature of 10°C which is not typical of *C. centrifugum*. The source of the inoculum for this disease is not known, but symptoms have been observed only after prolonged cold storage.

Last year (1978) a very high level of rot was found in a lot of Golden Delicious in cold storage at the Research Station. The orchard from which these apples came is being scrutinized to find the source of the inoculum. Results to date suggest that infection does not occur before mid-August.

### Routine evaluation of field resistance

A system to evaluate the development of resistance of fungi to fungicides has been developed to approximate the population dynamics of field conditions. It consists of a continuous culturing apparatus that maintains a representative fungal population. The population can be subjected to a fungicide to determine how rapidly a resistant population is generated.

A response pattern plotted for benomyl, a chemical for which a great deal of field data is available, indicates the rate at which resistant cells are generated. Also it shows that under normal conditions the resistant strains remain a small fraction of the total population because they have a slower growth rate than the normal, nonresistant strains. Comparing these rates with the rate for new chemicals for

which field data are not available should give some indication of the potential of the new chemical for generating resistant strains in the field.

### Little cherry disease in British Columbia

Indexing for little cherry disease in the greenhouse, formerly attempted unsuccessfully, was done successfully by growing inoculated Sam test trees in the greenhouse from February to May then moving them outdoors to a lightly shaded, frost-protected location. Red-leaf symptoms indicative of little cherry disease developed on test trees in early June.

In orchards where trees that developed little cherry disease in 1978 had been removed, other trees that would develop little cherry fruit symptoms in 1979 were not reliably detected by fluorescence microscopy, electron microscopy, the presence of specific ribose nucleic acids, or indexing on Sam.

A graft-transmissible agent which caused red-leaf symptoms on Sam test trees but which did not cause little cherry fruit symptoms was isolated from some orchard trees.

Attempts to transmit the little cherry virus by pollen, seed, soil, rubbing, cutting, or other artificial means were not successful unless some form of grafting was involved.

### Effect of virus inhibitor on apple chlorotic leaf spot virus

The effect of carboxamide Ribavirin on apple chlorotic leaf spot virus was tested under greenhouse conditions. This inhibitor had been used elsewhere to prevent the multiplication of human and animal viruses but had never been used against tree fruit viruses. The tests were conducted by treating young *Chenopodium quinoa* plants with various concentrations of Ribavirin before or after inoculation with the virus. The results showed that 500 ppm Ribavirin were most effective and caused only slight toxicity to the plants. At this concentration virus multiplication was completely inhibited if Ribavirin was applied between 2 days before and 8 h after inoculation of the test plants. It was shown that the inhibitor can be applied successfully by leaf spray, drench of the potting soil, or brief sand culture. Ribavirin is absorbed into the plant in less than 1 h and is rapidly translocated from the roots to the leaves. Tests are being continued to see whether the material can be used to eliminate virus from infected trees. It

may be especially useful in those cases where other methods such as heat treatment have not been successful.

## POMOLOGY AND VITICULTURE

### Thinning plus growth regulators improve grape yield and quality

Superimposed on cluster thinned and unthinned deChaunac grapes were gibberellic acid ( $GA_3$ ) at 50 ppm 1 wk after full bloom in 1976, 1977, and 1978; cycocel at 500 ppm 1 wk before full bloom in 1976; and benzyladenine (BA) in 1978. Thinning increased set (1976, 1977) and soluble solids and total sugar per vine (all years). It reduced acidity and improved tannin in 1976 but not in 1977 or 1978. Cycocel increased set but reduced quality while BA had no effect.  $GA_3$  plus thinning was the best treatment. Increased berry weight and soluble solids more than made up for reduced set and resulted in 18% more total sugar during the 3 yr.

### Gibberellic acid affects sweet cherry ripening

Lambert (L) and Compact Lambert (CL) were treated with gibberellic acid ( $GA_3$ ) at 40 ppm on 11 June, then ripening parameters were measured at weekly intervals until 17 July. Lambert developed 25% surface red on 26 June and CL on 1 July.  $GA_3$  delayed L coloring 5 days and CL 4 days but did not influence rate of increase of soluble solids or fruit weight. Respiration decreased each week, as expected, but ethylene increased after 3 July (beginning of stage III). The  $GA_3$  influenced fruit coloring but not other ripening parameters.

### Testing apple storage quality

Risk of Spartan breakdown is low at 30 ppm flesh calcium (fresh weight) if the fruit is sold before February. Calcium (Ca) levels change during growth and with season and location so it must be assayed 2 wk or less before harvest to accurately predict storage quality. Low-Ca fruit must either be dipped or sold after short storage. This year an atomic absorption procedure was developed to analyze 50 samples per person daily, with results available after 3 days. Of 78 orchards, one-third had Ca levels lower than 20 ppm, indicating high risk.

## In vitro propagation of pear and woody ornamentals

Large numbers of Bartlett pear plants were obtained from meristem-tip cultures. Only benzyladenine (BA) ( $5 \mu M$ ) was required for proliferation, giving a yield of 50 shoots per month from each culture. Inverting decapitated shoots in medium and regular pruning induced synchronous shoot growth and increased shoot number. Shoots rooted (70%) after 3 wk in  $10 \mu M$  NAA and were transferred to the greenhouse and field. *Spiraea bumalda* 'Anthony Waterer' and *Prunus cistena* yielded 300 and 35 shoots per cycle (respectively) in Murashige and Skoog medium with  $5 \mu M$  BA. Rooting was optimum at  $0.1 \mu M$  NAA (*Spiraea*) or  $1 \mu M$  (*Prunus*). These results show that woody as well as herbaceous species can be easily propagated from meristem tips in vitro.

### Training methods affect precocity of Anjou pears

Cumulative yield from the 1977, 1978, and 1979 crops was measured from the following treatments on trees planted  $2.44 \times 4.88$  m in 1974: normal pruning, spreading, planting at  $45^\circ C$ , spindle (branches tied down), and double arm  $45^\circ C$  with 30 cm high base. Spindle pruning yielded most, 19 t/ha, and double arm least, 5.75 t/ha. Spindle trees filled the space but were taller and required more labor than double arm.

### Pear variety testing

Swiss Bartlett compared to Bartlett was 3–5 days earlier and firmer at harvest maturity. Eating quality and flavor were excellent and acidity when ripe was greater than in Bartlett. Spartlett may prove valuable for winter sales because of good size, appearance, and general quality.

### Rate of cooling and CA establishment affects Golden Delicious apple quality

Experimental treatments included cooling to  $0^\circ C$  core temperature in 3 or 10 days with CA establishment in 2 or 20 days. Both fast cooling treatments resulted in fruit 0.35 kg firmer, but soluble solids and acidity were similar in all treatments.

### **Effect of temperature and keltrol concentration on calcium uptake by Spartan apple**

Keltrol/CaCl<sub>2</sub> solution temperature of 10°C resulted in 10–15% greater Ca uptake than at 20°C, probably because of higher viscosity. Four percent CaCl<sub>2</sub> with as low as 0.05% keltrol resulted in fruit Ca increased in the desired range of 140–150 ppm (dry weight). A drain time of 5 min reduced inconvenient spillage and was not slower than at 20°C at the 0.05% keltrol concentration.

### **Physiological injury to Delicious apples caused by ethoxyquin**

A CaCl<sub>2</sub>/keltrol/ethoxyquin dip plus CA storage resulted in soft scaldlike degradation combined with sharp, pungent taste uncharacteristic of soft scald. In air storage only small lesions developed, particularly where fruit touched. At lower ethoxyquin levels injury was reduced but scald was not controlled. Research to combine CaCl<sub>2</sub> and ethoxyquin effectively is in progress.

### **Nectarine variety testing**

Several recent acquisitions fruited and were assessed for the 2nd yr consecutively. John Rivers is a white-fleshed variety slightly later than N.J. N-21, with little promise of proving to be superior. Pocahontas is a promising yellow fleshed, highly colored early variety which to date has proved firmer than any cultivar ripening in the same season. Hardired has fruited so heavily, despite normal thinning, that extra care and expense would be involved in its culture. It matured with Early Sungrand and Nectared 5, and though equal or better in flavor than Nectared, it was rated well below Early Sungrand.

## **SOIL SCIENCE AND AGRICULTURAL ENGINEERING**

### **Herbicides for apple and grape 1st yr plantings**

The best single herbicide treatment for the control of weeds in a newly planted apple orchard on M-26 rootstock was a directed application of oxyfluorfen at 2 kg/ha when weeds were 5 cm high. This treatment provided contact and residual control of all weeds for more than 2 mo. Trifluralin applied

pretransplant-incorporated followed by oxadiazon granular posttransplant gave good weed control until midsummer.

Two treatments provided excellent weed control in newly planted Himrod grapes with no apparent phytotoxicity to the grape plants. Two applications of oryzalin plus napropamide, each at 4 kg/ha in spring and midsummer, and trifluralin pretransplant at 0.8 kg/ha followed by oryzalin at 4 kg/ha posttransplant gave almost complete weed control throughout the season.

### **Quack grass inhibition of apple seedling growth**

The growth of apple seedlings in the same nutrient solution containers as quack grass plants was severely inhibited, notwithstanding adequate supplies of essential nutrients and water, and lack of competition for light. When quack grass plants were grown in a nutrient solution for 1 wk and replaced by apple seedlings, their growth was also severely inhibited. Normal growth of either groups resumed when transferred to fresh solutions.

### **Calcium nutrition**

Leaf and soil analyses were continued on the soil calcium experiment commenced in 1974 in the substation orchard. Mean fruit weight and fruit Ca have been unaffected by any treatment for the 1975–1978 apple harvests. Significantly depressed leaf Zn and leaf Mn were measured during 1978 for a number of the Ca(OH)<sub>2</sub> treatments. Soil sampling to 60 cm depth in the treated plots indicated that significantly increased soil pH and increased exchangeable Ca were restricted to the top 10 cm of the soil. Thus, 5 yr after Ca application to the surface of the soil, the failure of fruit Ca to show significant increase may reflect the lack of significant Ca increase in the main tree rooting zone.

Systematic soil sampling around two fruit trees at three depths identified a surface zone (0–20 cm depth) encircling the trees at 1–2 m from the trunk with depressed extractable cations and decreased pH. This surface zone was tentatively associated with a previous banded surface application of NH<sub>4</sub>SO<sub>4</sub> fertilizer.

## Soil N in field plots

Elevated soil NO<sub>3</sub>-N values were found in herbicide-treated plots compared to sod plots. Both plots were fertilized with N at 100 kg/ha. Plot differences persisted throughout the growing season (April–October). Large soil NO<sub>3</sub>-N reductions had occurred under grass by May after fertilization on 10 April. In contrast, high soil NO<sub>3</sub>-N values persisted in herbicide-treated plots until October. This could represent a potential for winter damage to fruit trees.

## Trickle irrigation

Monitoring of 10 field trickle systems in commercial orchards has revealed that since intermittently operated systems plug only rarely, chlorine injections have little or no effect on the incidence of emitter plugging even with suspended solids up to 10 ppm. The chlorine treatment is effective in continuously operated systems although some plugging occurs despite chlorine treatment.

## Lysimeter studies: results from 1 October 1978 to 30 September 1979

From large lysimeters containing a sandy loam soil in which 5 yr old McIntosh apple trees are growing, only 10% and 15% of the irrigation water plus rain and snow was returned as drainage water under grass cover crop and clean cultivation, respectively. The 12 mo application of water was 692 mm as

irrigation and 208 mm as natural precipitation. Despite the small return flows of water, nitrogen losses differed widely depending upon the presence or absence of grass and upon the rate of N fertilization. Rates of elemental N application were 162 and 324 kg/ha. At the low rate, N losses to groundwater were 6 and 81 kg/ha under grass and bare ground, respectively. At the high rate, N losses to groundwater were 48 and 139 kg/ha under grass and bare ground, respectively. The different rates of N fertilization showed no differences in tree performance. The higher N losses represent potentially serious losses of N and contamination of groundwaters. Grass cover is obviously a key factor in retaining nitrogen but apparently even that can be overloaded with too high an application of N.

## Fruit drying

A prototype commercial fruit dryer was designed and constructed following experimental tests on the drying of purées into fruit leathers. The tests investigated the effects of air temperature, air velocity turbulence, tray spacing, and tray material. The resulting dryer incorporated a moveable tray dolly, a 633 MJ/h gas heater and a 9440 dm<sup>3</sup>/s air blower. The unit was capable of dehydrating 680 kg of purée into 136 kg of fruit leather in about 4 h. It is now in commercial production where, by completely filling the trays, 227 kg of leather are produced from 1134 kg of purée in about 8 h.

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# Research Station

## Vancouver, British Columbia

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## INTRODUCTION

The Research Station, Vancouver, is the national center for plant virus research, and additionally serves regional agriculture in problems of plant pathology and entomology. Consequently, this report deals with various aspects of plant virology and virus diseases, ranging through investigations of the virus entities *in vitro*, their mode of transmission, and their biochemical and ultrastructural effects, all of which culminate in symptom expression and economic crop loss. The report also gives results of research aimed at helping to solve agricultural problems of an immediate and urgent nature, such as the little cherry disease, local epidemics by fungi or insects in small fruit crops and vegetables, and biological control of noxious weeds both in the lower mainland and in the interior.

Requests for details of our research program, for reprints of this report, or for reprints of publications listed should be addressed to individual scientists or to: Research Station, Research Branch, Agriculture Canada, 6660 N.W. Marine Drive, Vancouver, B.C. V6T 1X2.

M. Weintraub  
Director

### VIRUS CHEMISTRY AND PHYSIOLOGY

#### Physical, chemical, and serological properties of viruses *in vitro*

Limited proteolysis of the bean and cowpea strains of southern bean mosaic virus yielded approximately 12 peptides from each strain. The peptides isolated from each strain had similar but not identical amino acid composition and the one peptide from each strain contained the acetylated N-terminal amino acid. Cyanogen bromide (CNBr) cleavage of the whole coat protein of each strain yielded a highly basic peptide (DB-1) from each. The peptide from the bean strain contained 48 amino residues but the peptide from the cowpea strain contained 52 amino acids. Cleavage of these basic peptides with trypsin yielded most of the peptides isolated by limited proteolysis of the whole virus including the peptide containing the acetylated N-terminus. These CNBr peptides are therefore the N-terminal regions of the virus coat proteins. In experiments with the bean strain, antiserum to SDS-dissociated virus reacted with the CB-1 peptide and gave a reaction of partial identity when the CB-1 peptide and the SDS-dissociated virus were compared in gel diffusion tests. The CB-1 peptide did not react with antiserum to SDS-dissociated trypsin-treated virus. Gel diffusion tests between trypsin-treated virus and SBMV, with SBMV antiserum, did not show differences in their serological properties.

The amino acid composition, behavior in SDS-polyacrylamide gel electrophoresis, reaction with 2,4,6-trinitrobenzenesulfonate (TNBS), and electrophoretic patterns of CNBr peptides of tobacco etch virus (TEV) capsid protein were compared before and after limited proteolysis by storage at 4°C or by trypsin treatment. About 45% of the lysine residues were lost, while only 20% of the capsid protein chain was cleaved during limited proteolysis. Reaction of TEV with the lysyl-specific reagent TNBS, before and after limited proteolysis, suggested that at least six lysyl residues per protein subunit were lost during the degradation. The electrophoretic patterns of CNBr peptides revealed the loss of at least two protein fragments upon the limited proteolysis of the capsid protein. These results indicate that the condition of the capsid protein must be defined when the above properties are to be used in potyvirus characterization.

#### Virus infection

Attempts to obtain *in situ* evidence for virus receptor sites on leaf outer cell walls and to establish the pathway followed by the virus on its way to the leaf cell protoplasts were continued. In this context, the effect of Pb acetate on leaf surfaces was examined, as reflected by changes in the number of virus-induced primary lesions and by Pb deposits visible by electron microscopy. Pb acetate treatment reduced the number of lesions caused by TNV on *Phaseolus vulgaris* by at least 50%; *in vivo*, the outer cell wall was

permeable to Pb, and the pathway followed may be determined by an irregular network of channels running from the cuticle to the plasmalemma. Occasionally some Pb was deposited nondestructively within the protoplast of epidermal and mesophyll cells.

Several compounds were tested for their in situ effect on virus infection. The neutral detergent X-100 suppressed local lesion development when leaves were treated with dilute solutions of the detergent after inoculation, but not when leaves were treated prior to inoculation. Detergent applied simultaneously with the virus also had no effect, even at a concentration five times higher than used in the separate applications. Bentonite, dusted on leaves prior to virus inoculation, reduced local lesion development to less than 10% of controls. This effect could not be attributed to direct virus-bentonite interaction on the leaf surfaces, since supernatants of low-speed-centrifuged mixtures with bentonite-to-virus ratios greater than those on the leaves during inoculation did not show the same reduction in lesion numbers. The effect of early treatment of inoculated leaves with RNase solutions was strong and highly concentration-dependent, possibly indicating competition between enzyme and virus for receptor sites. The effect of treatment  $\frac{1}{2}$ -2 h after inoculation was weaker and far less dependent on enzyme concentration, possibly reflecting enzyme action on exposed viral RNA. These hypotheses are being investigated further.

### Biological properties of viruses

It was demonstrated that in mixed infections pseudorecombinants could be formed between the genomic RNAs of strains of cherry leaf roll virus (CLRV), and that parental types could be regenerated. Furthermore, RNA 1 determined the type of local lesion in *Nicotiana clevelandii*, and the ability to induce systemic symptoms in *Gomphrena globosa*; RNA 2 determined systemic symptoms in *N. clevelandii* and *N. tabacum* (cvs. Xanthi and Samsun), and local and systemic symptoms in *Chenopodium* spp.

### Ultrastructural responses to virus infection

A comparative study involving at least seven plant families and 26 species revealed that two types of membrane-bound cytoplasmic crystals occur, with fine or coarse elements, and that each type may be restricted to certain families. If confirmed, this feature

would be a potential taxonomic characteristic. The coarser crystals were widespread among Compositae, with some species in this family having similar but nonmembrane-bound crystals in their chloroplasts. A possible link between catalase and the chloroplast crystals is being considered.

### Virus transmission by seed and pollen

Attempts were made to improve the serological assay for pea seed borne mosaic virus in pea and other legumes. The latex agglutination test appears promising for both leaf and seed extracts. By this test the virus can be detected in samples containing only 2-3% infected material. Furthermore, the test requires considerably less antiserum than the currently used gel diffusion method.

### Aster yellows disease

The pathological effects of mycoplasma-like organisms in plants often result from subtle changes in auxin levels. Because of the extremely low concentration of the active compounds, quantitative estimates are very difficult. The biological assay method for auxin was variable and cumbersome, so an immunoassay method was considered, which requires as a first step complexing of auxin to bovine serum albumin (BSA). Therefore, a BSA-auxin hemisuccinate conjugate was prepared, which when assayed by differential UV analysis, contained approximately eight to nine molecules of auxin hemisuccinate per BSA molecule. The complex was purified and injected into rabbits. The antiserum was purified by ammonium sulfate precipitation and ion exchange chromatography. It showed a specific titer of 1:320 and a nonspecific titer of 1:20. The immunoassay of auxin by the enzyme-linked immunosorbent assay (ELISA) method is now in progress.

### Little cherry disease (LCD)

Research was directed mainly toward diagnosis of diseased trees by other than fruit symptoms, and isolation of the disease agent or agents. Light microscopy revealed the presence of many  $\text{CaCO}_3$  crystals in the petiole tissue of some diseased experimental trees. Subsequent analysis of extracts from healthy and diseased tissues by atomic absorption spectroscopy revealed that Ca levels appear to be lower than Mg levels in diseased tissue, and higher than Mg in healthy tissue.

Potassium levels showed no difference. Ultra-violet and visible light spectroscopy of the extracts showed no qualitative differences in the 250–700 nm range, but interesting quantitative differences were observed in the 250–300 nm range.

Leaf rooting experiments to obtain suitable tissue for preparative isolation of the LCD agent(s) progressed only to the callus formation phase. Attempts to find a herbaceous host by leaf grafting or incision inoculation also were inconclusive. Therefore, isolation was attempted directly from cherry leaf tissue, which is generally unsuitable for virus isolation. To overcome the destructive conditions in the extracts an entirely new isolation procedure was developed, which is yielding preparations of viruslike rod-shaped particles 1–1.2 nm by 11 nm. In the course of this work a spherical virus, differing from the usual cherry viruses, was also isolated from the LCD material, and an unusual pollen-borne spherical virus was found associated with pollen from Stella (*Prunus avium*).

## PLANT PATHOLOGY

### Virology

*Virus identification and characterization.* A virus, tentatively designated 'blueberry leaf mottle virus', was isolated from highbush blueberry, *Vaccinium corymbosum*. The virus is serologically related to the nematode-transmitted grapevine Bulgarian latent virus.

Potato leaf roll virus was purified. Its antiserum, used in enzyme-linked immunosorbent assay (ELISA), consistently detected the virus in infected foliage but not in dormant tubers. Characterization studies showed that the virus is a member of the luteovirus group and that its ribonucleic acid has a molecular weight of  $2.0 \times 10^6$ .

Raspberry bushy dwarf virus in raspberry can cause some leaf abnormalities, crumbly fruit, and yield reduction. Sap transmission from raspberry to *Chenopodium quinoa* was determined to be a reliable indexing method. Failure to recover raspberry bushy dwarf virus from certain raspberry selections which had been graft inoculated indicates that a source of immunity exists among some cultivars.

### Virus-free potatoes

Twenty-three new accessions were rendered virus-free by heat therapy and meristem tip propagation. The virus-free potato collection currently contains 52 cultivars now licensed for seed certification in Canada and 75 others. Twelve of the licensed cultivars are represented by two to nine clones from separate sources. In 1979, 139 tuber samples were sent on request to potato improvement agencies, growers, or research establishments in seven provinces, five states, Australia, Brazil, The Peoples' Republic of China, and USSR.

The annual survey for potato viruses X and S in seed potato control areas involved 200 ha of Elite and Foundation seed. Neither virus was found on 23 of the 28 farms surveyed. Of the total, 166 ha (83%) were apparently virus-free; the remainder contained up to 6.4% infection as estimated from confidence interval tables ( $P = 0.05$ ).

### Small fruits

*Strawberry.* The red stele disease of strawberry, caused by *Phytophthora fragariae*, was controlled by drenching soil in spring and fall for two successive years with either of two test fungicides, LS 74-783 (Aliette, Rhône-Poulenc Phytosanitaire) and CGA 48988 (Ridomil, Ciba Geigy Corp.).

The strawberry selection 70-17-12 has been named Tyee. This new cultivar has tolerance or resistance to viruses, red stele, powdery mildew, fruit rot, and the twospotted spider mite, is well adapted to the Fraser Valley and Pacific Northwest, and will serve the fresh-fruit and processing markets.

Two strawberry viruses, mottle and mild yellow edge, were eliminated consistently from meristem tips excised from plants that had been subjected to 37–40°C for 5–7 wk. A third virus, veinbanding, was seldom eliminated by this treatment.

*Raspberry.* Current selections from the British Columbia raspberry breeding program are immune to *Amphorophora agathonica*, the aphid vector of red raspberry mosaic virus, resistant to spur blight caused by *Didymella applanata*, have the relatively smooth canes and upright growth habit that facilitate pruning and training for mechanical harvesting, and have desirable fruit characteristics including resistance to postharvest rot. The cultivar Haida, released in 1973, and Skeena, released in 1977, showed superior

winterhardiness during the winter of 1978–1979. Genetic studies on the inheritance of resistance to *A. agathonica* have shown that in some cultivars, e.g. Mitra, the presence of one dominant gene in either of two gene pairs will determine immunity; in others, e.g. Lloyd George, aphid immunity is controlled by a single pair of genes.

### Bacteriology

Serogroups of *Erwinia carotovora*, the potato soft rotting and blackleg bacteria, are established by grouping isolates shown to be closely related in double diffusion serological tests. Tests in 1979 included serogroup determination of 250 *E. carotovora* isolates from Peru, Scotland, Wisconsin, and Oregon. Results of these tests increased the number of serogroups from 18 to 26. Epidemiological studies, which involved isolations from potato tubers grown in infested soil, showed that *E. carotovora* isolates that overwinter in the soil are not necessarily a major source of inoculum.

*Pseudomonas syringae* was identified as the causal agent of a leaf spot that extensively damaged cherry laurel, *Prunus laurocerasus*, in lower Fraser Valley nurseries. Streptomycin resistance was common among isolates from nurseries where this bactericide had been used.

### Nematology

The toxicity to nematodes of fatty acids, their potassium salts and methyl esters, was measured in vitro and in the greenhouse. Potassium decanoate was the most effective in vitro: 50 ppm achieved total control. In soil, this chemical was not nematocidal. Gas chromatography of soil solutions showed that 90% of this salt was insolubilized. In infested greenhouse soil, good control was achieved with a drench of methyldecanoate.

## ENTOMOLOGY

### Vectors

*Little cherry disease.* Dodder was shown to be an effective vector of all three cellular inclusions associated with LCD. Maximum transmission occurred when the junctions between source and receiver trees were maintained for 30 days. Attempts to transmit the inclusions by dodder from cherry to 27

herbaceous hosts, mostly Rosaceae, were unsuccessful.

*Morphology and fine structure.* The sensoria on the antennae of 28 species of aphids from five subfamilies were compared by scanning electron microscopy. Several types of primary sensoria were identified according to the number and arrangement of multiporous plate organs and uniporous pegs included in the sensorium. Mechanosensilla of three types were also identified. Hind tibiae of the ovipara of nine species were examined by scanning electron microscopy. Only *Tamalia coweni* (Cockerell) lacked pseudosensoria. The stylets of a new species of aphid, *Glabromyzus* sp. nov., were sectioned and examined by transmission electron microscopy. As with all true aphids previously examined, the mandibular stylets were innervated by two dendrites contained in a central canal.

*Aphid survey.* Fourteen species of aphids new to the province were identified. Eight of these were trapped in yellow pan water traps and six were collected on a host plant. Another 28 new records are presently identifiable only to genus: one genus was not previously known from British Columbia and two species are new to science. The number of aphid species now known in British Columbia is 325.

*Aphid ecology.* A predacious anystid mite was implicated as the regulating factor of pea aphids on alfalfa on the basis of field experiments in which large predator exclusion cages and a previously developed model of the aphid's population dynamics were employed. Samples from the cages before, during, and after aphid population explosions were used to evaluate abundance of natural enemies. The only difference between the faunas inside and outside the cages was a depauperate population of anystid mites when aphids increased most rapidly. Data collected for developing a model of the population dynamics of the cabbage aphid included the effect of planting time on the rate of aphid increase; the growth of the host plant as expressed by the fate of its individual leaves; the survival of aphids on dying leaves; and the predatory efficiency of a dipterous midge (Cecidomyiidae).

*Aphid vector-virus relationships.* When *Myzus persicae* (Sulzer) from potato leaf roll source plants were fed for up to 15 days on PLRV-immune Chinese cabbage, they usually maintained their ability to transmit but

the rate of transmission was often reduced. Detection of potato leaf roll viruslike particles in honeydew from infective aphids was not always achieved by the usual methods of negative staining, nor did the honeydew give a positive result in the ELISA test for PLRV.

### Pest control

*Leatherjackets.* To determine population trends during the period of greatest growth and development leatherjackets, *Tipula paludosa* Meigen, were counted from January to August. Fifty larvae from each collection were dissected and examined for parasites. The number of leatherjackets reaching the prepupal and pupal stage in August dropped to 55/m<sup>2</sup>, the lowest since 1975. Parasitism by the first generation of the tachinid fly, *Siphona geniculata* De Geer, was only 0.5% but in the second generation it was 6%. Leatherjackets were again heavily parasitized by Protozoa. *Diplocystis* sp., *Actinocephalus tipulae* Léger, *Gregarina longa* (Léger), *Hirmocystis ventricosa* (Léger), and *Nosema binucleatum* Weissenberg were found in most collections and peaked 30 May when each protozoan was found in 74% of the larvae examined. Leatherjackets received from Newfoundland on 14 June had only three protozoan parasites: *Diplocystis* sp. (92%), *G. longa* (87%), and *H. ventricosa* (3%). No *S. geniculata* have been found in larvae collected from the release site near St. John's, Nfld.

*Weeds.* The gall fly *Urophora styllata* F., which attacks the flowers of bull thistle, was released at two sites in 1973. In 1978, 32% of the thistle heads at Ladner were infested; in 1979, 46%. At Cloverdale 96% were infested in 1978; 84% in 1979. Infested bull thistles were found 1 km east of the Cloverdale release site. An additional 3000 flies were released in the Cariboo and are well established near Williams Lake.

*Ceutorhynchus litura* F., a weevil whose larvae mine the stems and crowns of Canada thistle, was released at Ladner in 1975. In 1979, 55% of the thistles were infested compared with 11% in 1976 and 58% in 1978. There has been no change in the population of thistles.

Larvae of the flea beetle *Longitarsus jacobaeae* (Waterh.), released to control tansy ragwort, were found in the roots and crowns of all the 12 plants examined at the Nanaimo release site, with an average of 40 per plant. At Abbotsford only eight of the twelve plants

examined were infested, with an average of three per plant. In 1979, 350 adults were transferred from Abbotsford to a site near Chilliwack and another 200 to a site near Cultus Lake. The cinnabar moth larvae stripped 50% of the flowering stalks but 50% of those recovered by mid-August. Both rosette and flowering stalk numbers were down this year.

*Root maggots, aphids, and caterpillars on brassicas.* Band and in-furrow applications of granular or liquid insecticides were tested for control of cabbage maggots in broccoli and cauliflower. Chlorfenvinphos, fonofos, isofenphos, and terbufos all provided good protection against cabbage maggots. Chlorfenvinphos and fonofos granules were phytotoxic when applied in the furrow.

Combination sprays were compared to control aphids and caterpillars on Brussels sprouts. Methamidophos and pirimicarb with permethrin or *Bacillus thuringiensis* gave the best overall protection; disulfoton and Safer's soap (potassium oleate) had no effect.

*Integrated control of root maggots of brassicas.* Several years' experiments to test the interactions among the insecticides (carbofuran, chlorfenvinphos, isofenphos), the carabid predators of root fly eggs, the staphylinid parasite *Aleochara bilineata* Gyll., and the cabbage root maggots have shown that chlorfenvinphos is the insecticide most effective against the pest with least damage to natural controls.

*Onion maggots.* Four granular and six liquid insecticides were applied with and without formaldehyde against onion maggots in the furrow with the seed. All allowed less than 4% loss of plants to onion maggots; untreated plots averaged 95% loss. Supplementary sprays did not improve the treatment. Ethion and isofenphos gave the highest yields of marketable onions.

*Carrot rust fly.* In an experiment to compare furrow and band applications of granular and liquid insecticides against the carrot rust fly, infestation was too low to give meaningful efficacy data. Diazinon and profenfos in the furrow were phytotoxic, reducing the number of seedlings emerging.

*Pests of small fruits.* The strawberry tortrix, *Acleris comariana* Zeller, first reported by us in 1972 as a pest of strawberry, was held at low levels by chemical control and

parasites until 1979, when a large population reappeared at the original infestation site in Richmond and, for the first time, in the major strawberry production areas around Abbotsford about 60 km east of Richmond. Counts at Abbotsford suggested preferential feeding: the heaviest infestations were on Tyee, Shuksan, and Totem while there were almost no larvae on three new selections. A laboratory test, however, showed that one of the selections was not immune to larval feeding, so it appears that the moth shows a nonpreference for this selection for oviposition.

Populations of two species of cutworms, *Peridroma saucia* (Hubner) and *Autographa ampla* Wlk., were monitored in early spring when raspberry growers were alarmed on seeing the cutworms climbing the canes and chewing off the new buds. No chemical control was recommended and the raspberries recovered, later producing high yields. Other pests of sporadic or potential importance on small fruits were also monitored including: a plant bug, *Lygus varius* Knight, which was abundant on strawberry and apparently causing severe fruit deformity; root weevils; leafrollers and spanworms on blueberry; and the cranberry girdler, *Chrysoteuchia topiaria* (Zeller), on cranberry.

*Pests of potatoes.* The European wireworm *Agriotes obscurus* (L.), first found at Agassiz in 1952, is now causing severe damage to potatoes near Cloverdale. In the past 2 yr it has been found on an additional 10 farms distributed over 3200 ha. In tests to control it, in silt loam near Agassiz, fonofos was applied by furrow or broadcast, terbufos by furrow, and chlordane broadcast. The broadcast treatments were rototilled to a depth of 10 cm. Chlordane broadcast with active ingredient at 11.2 kg/ha and fonofos broadcast with active ingredient at 5.6 kg/ha reduced wireworm damage to potatoes by 78–79%. Furrow treatments with active ingredient at 1 or 2 kg/ha failed to protect potatoes adequately.

In the same experiment, damage (unmarketable tubers) by flea beetle ranged from 63% to 100% after soil treatment alone, from 15% to 93% after only spray application to the foliage, and from 2% to 72% after both soil and foliar treatments.

In muck soil near Cloverdale, chlordane broadcast with active ingredient at 11.2 kg/ha reduced wireworm injury by 54% and fonofos

broadcast with active ingredient at 5.6 kg/ha reduced injury by 68%. In peat, chlordane broadcast with active ingredient at 11.2 kg/ha gave inadequate protection.

Tubers from all chlordane-treated plots were analyzed for residues. Chlordane residues were higher and wireworm control was more effective in the soils with lower organic content. Chlordane residues in potatoes were 0.26 ppm in silt loam; 0.3 ppm in well-decomposed peat and clay; 0.01 ppm in peat.

*Wireworms on corn.* Chlordane broadcast with active ingredient at 11.2 kg/ha and fonofos broadcast with active ingredient at 4.6 kg/ha reduced the number of wireworms in sweet corn by 96–98%.

### Stored products and household pests

Inspection of flour warehouses and feed plants on Vancouver Island revealed Mediterranean flour moths, white shouldered house moths, Australian spider beetles, varied carpet beetles, larder beetles, confused flour beetles, and yellow mealworms. Advice was given on appropriate control measures.

Two mites, *Dermatophagoides pteronyssinus* (Trouessart) and *D. farinae* (Hughes), were found in mattress dust collected at monthly intervals for 2½ yr. There was a significant association between mites and relative humidity. Live mites were seen only when the relative humidity had been  $\geq 50\%$  for at least part of every day during the month of collection. Live mites were found only in the warmer months, not in the winter. However, the peak in the mite population was consistent neither for month nor for numbers. In 1977 a slight peak in mite numbers occurred in October; in 1978 the peak was higher and occurred in July.

Requests for the identification of insects and for information on their control were received from government agencies, industry, and the public. Records of inquiries received over more than a decade were summarized and analyzed.

### Residue chemistry

A method for the analysis of technical chlordane was adapted for determining these residues in field-treated potatoes. Results showed that residues in harvested crops were related to the organic content of the soil. The highest residues found were approximately 0.3 ppm.



In an investigation of the nematocidal properties of long-chain fatty acids, a method was developed for the analysis of capric and caprylic acid residues in water and soil. Using  $\text{BF}_3$  in methanol the acids were alkylated to the methyl esters, then determined by flame ionization gas—liquid chromatography. The fatty alcohol, decanol, could be determined directly without derivatization and a method was developed to extract decanol from field-treated soils.

A satisfactory method was finally found for the analysis of Temik (aldicarb) and its sulfoxide and sulfone oxidation products by adapting a recently published method that involves chromatographic separation of the

three compounds and oxidation of the parent and the sulfoxide to the sulfone. In potatoes that had been field-treated with Temik the highest residues,  $\geq 0.2$  ppm, were found at the highest application rates: with active ingredient at 4 kg/ha in the furrow or 5.5 kg/ha broadcast.

A study of the dissipation or degradation of residues of carbofuran, chlorfenvinphos, and isofenphos in carrots in frozen storage ( $-18^\circ\text{C}$ ) was carried out over 160 days. The carbofuran portion was discontinued owing to low initial residues. Some chlorfenvinphos in the samples dissipated during the first 40 days of storage. Some isofenphos was dissipated during the study and some was converted to the phosphoramidate analogue.

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# PROGRAM STRUCTURE OF THE RESEARCH BRANCH

## Departmental aim

The basic aim for Agriculture Canada, within the framework of overall government objectives and in cooperation with provincial governments, is to develop and assist the Canadian agricultural and food system, to provide for the needs of Canadians, for export markets, and for international aid commitments in a manner which assures: (a) a dependable supply of safe, nutritious food at reasonable prices to consumers; and (b) equitable returns to producers and processors.

## Branch objectives and goals

### LAND

#### 1 Soil management and conservation

To obtain an understanding of the properties that limit the productivity of selected soils.

GOAL 1: SOIL PROBLEMS. By 1982, to have produced information that will provide a basis for improved management of selected problem soils, by studying their chemical, biological, and physical properties.

#### 2 Land use and capability

To obtain a reliable inventory of Canadian soils and to develop improved methods for their characterization, classification, and evaluation.

GOAL 1: SOIL SURVEY AND CLASSIFICATION. By 1980, to have promoted better utilization of the soil resources in selected regions of Canada, by developing a soil inventory and more reliable methods and criteria for classifying and mapping soils.

GOAL 2: LAND EVALUATION. By 1982, to have developed procedures for evaluating the capability of Canadian soils for agricultural production.

### WATER

#### 1 Irrigation, drainage, and desalination

To improve water management, irrigation, and drainage on Canadian soils in order to increase productivity.

GOAL 1: IRRIGATION, DRAINAGE, AND DESALINATION. By 1982, to have increased the production potential of selected soils, by improving water use efficiency and by developing superior methods of irrigation, drainage, and desalination.

#### 2 Meteorological and climatic indices

To increase the use of climate resource information.

GOAL 1: METEOROLOGICAL AND CLIMATIC INDICES. By 1980, to have increased the use of climate resource information in weather-sensitive agricultural operations, in assessing productivity, and in research applications, by improving methodology, assessing and interpreting available data, and deriving selected meteorological and climatic indices.

### ENERGY AND ENVIRONMENTAL QUALITY

#### 1 Energy

To improve on-farm production and the use and conservation of energy.

GOAL 1: ENERGY UTILIZATION AND CONSERVATION. By 1982, to have reduced the farmer's dependence on fossil fuels and to have reduced energy costs in production, by applying known technology and developing and applying new technology.

#### 2 Environmental quality

To develop agricultural management practices consistent with production and environmental requirements.

GOAL 1: RESIDUES AND PLANT NUTRIENTS. By 1982, to have provided information and to have developed and applied technology for controlling pollution from the plant nutrient and residue components of selected animal and crop production systems, by conducting field and laboratory studies and by developing and evaluating equipment.

GOAL 2: PESTICIDE MANAGEMENT. By 1980, to have established economic criteria for and to have determined the environmental acceptability of existing and new pesticide management systems, by using models, studying pesticides and their residues in soil, and developing and improving methods and equipment.

## PRODUCTION DEVELOPMENT—ANIMALS

### 1 Beef cattle

To improve the efficiency of beef production and the quality of beef products.

GOAL 1: SELECTION AND CROSSBREEDING. By 1982, to have provided new information that will make possible a 5% increase in beef yield per breeding cow, while maintaining or improving carcass and meat quality, through a program of selection and crossbreeding.

GOAL 2: COW-CALF SYSTEMS. By 1982, to have provided new information that will make possible increases of 7% in calf yield per cow and 25% in calf yield per hectare, by conducting multidisciplinary research on cow-calf systems, rangeland, forage crops, and crop residue utilization.

GOAL 3: FEEDLOT SYSTEMS. By 1982, to have developed more economical feeding and management systems, superior methods for processing and utilizing crop by-products and residues as feed, preventive measures against metabolic disorders and deficiencies, and greater control of carcass composition.

GOAL 4: INSECT PESTS. By 1983, to have developed methods of measuring levels of parasitic infections in ruminants; defined the host-parasite interactions regulating parasitic populations of free-living blood-sucking flies in the environment of cattle and man; and to have elucidated mosquito populations, ecology, and control influencing Western encephalitis virus infection.

### 2 Dairy cattle

To improve the efficiency of milk production.

GOAL 1: BREEDING, GENETICS, AND MANAGEMENT. By 1980, to have provided new information that will make possible a 10% improvement in overall efficiency of milk production, by improving crossbreeding and intensive management systems.

GOAL 2: NUTRITION AND MANAGEMENT FOR MILK PRODUCTION. By 1981, through a systems approach, to have provided new information and superior techniques that will make possible more economical utilization of feed resources for milk production under various geographic and economic environments.

### 3 Swine

To improve the efficiency of swine production and the quality of pork and pork products.

GOAL 1: SWINE. By 1981, to have provided new information that will make possible a 5% increase in yield of pork per unit feed energy, while improving pork quality, through research on breeding, reproductive physiology, and superior feeding and management systems.

### 4 Poultry

To improve the efficiency of production of eggs and poultry meat and the quality of the products.

GOAL 1: POULTRY. By 1982, to have provided new information on breeding, feeding, and management of laying hens that will make possible increases of 4% in the weight of eggs and 10% in yield of meat per unit feed energy, and new information on the factors influencing interior and shell quality of eggs, through breeding and selection, reduction of metabolic disorders, and development of superior feeding and management systems.

### 5 Sheep

To improve the efficiency of sheep production and the quality of mutton and lamb products.

GOAL 1: SHEEP. By 1982, to have provided new information that will make possible increases of 15% in lamb production per ewe and 5% in growth rate of lambs, through breeding, improved reproductive efficiency, and development of superior feeding and management systems.

### 6 Honey bees and other animals

To improve the efficiency of production of honey bees and other animals, and the quality of their products.

GOAL 1: HONEY BEES. By 1982, to have provided new information that will make possible a 2% increase in the productivity of honey bees, by applying knowledge of pheromone chemistry, controlling disease, and improving management practices.

GOAL 2: FUR-BEARING ANIMALS. By 1979, to have made possible a 5% increase in the

productivity of fur-bearing animals, by improving feeding systems, reducing losses caused by disease, and increasing understanding of reproductive processes. (Extramural research only.)

## PRODUCTION DEVELOPMENT—CROPS

### 1 Wheat

To increase production, protection, and utilization of wheat through multidisciplinary research.

GOAL 1: WHEAT. By 1982, to have provided new information and technology that will make possible a 10% increase in unit yield of durum, winter, and spring wheats, while maintaining the quality of each crop to meet market demand, by developing superior varieties and improving management practices.

### 2 Other cereal crops

To increase production, protection, and utilization of other cereal crops through multidisciplinary research.

GOAL 1: BARLEY. By 1981, to have provided new information and technology that will make possible a 5% increase in unit yield of barley, while maintaining quality to meet market demand, by developing superior varieties and improving management practices.

GOAL 2: OATS. By 1981, to have provided new information and technology that will make possible a 5% increase in unit yield of oats, while maintaining quality to meet market demand, by developing superior varieties and improving management practices.

GOAL 3: CORN. By 1982, to have provided new information and technology that will make possible a 10% increase in unit yield of grain corn or silage corn, while maintaining quality to meet market demand, or a 1% increase in the area cropped with corn, by developing superior inbred or hybrid varieties of grain and silage corn and improving management practices.

GOAL 4: RYE. By 1982, to have provided new information and technology that will make possible a 10% increase in unit yield of winter rye, by developing superior varieties and improving management practices.

### 3 Oilseed crops

To increase the efficiency of production, adaptability, and quality of oilseed crops and their products through multidisciplinary research.

GOAL 1: RAPESEED AND MUSTARD. By 1981, to have provided new information and technology that will make possible a 3% increase in unit yield of rapeseed and mustard, and an improvement in the quality of the seed and processed products to meet market demand, by developing superior varieties, improving management practices, and conducting utilization research.

GOAL 2: SUNFLOWERS. By 1982, to have provided new information and technology that will make possible a 10% increase in unit yield of sunflower seed in the Black soil zones, and will enable the commercial production of sunflowers in the Brown soil zones, while maintaining or improving the quality of the seed and processed products to meet market demand, by developing superior inbred and hybrid varieties and improving management practices.

GOAL 3: SOYBEANS. By 1979, to have provided new information and technology that will make possible a 5% increase in unit yield of soybeans, and will give an indication of their value as a crop in nontraditional regions, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management practices.

GOAL 4: FLAX. By 1982, to have provided new information and technology that will make possible a 5% increase in unit yield of flax, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management practices.

### 4 Forage crops

To increase the efficiency of forage crop production systems and the quality of forage crops through multidisciplinary research.

GOAL 1: FORAGE LEGUMES. By 1982, to have provided new information and technology that will make possible a 10% increase in unit yield of digestible dry matter in forage legume crops, by developing superior varieties, improving management practices, and increasing seed production.

GOAL 2: FORAGE GRASSES. By 1982, to have provided new information and technology that will make possible a 10% increase in unit yield of digestible dry matter in forage grasses, by developing superior varieties, improving management practices, and increasing seed production.

### 5 Horticultural crops

To improve the efficiency of production and the quality of horticultural crops through multidisciplinary research.

GOAL 1: TREE FRUITS. By 1982, to have developed new information and technology that will make possible a 10% increase in unit yield of tree fruits, while maintaining or improving their quality for fresh and processed use, by developing superior cultivars and improving management and utilization practices.

GOAL 2: BERRIES. By 1982, to have developed new information and technology that will make possible a 5% increase in berry yield, while achieving higher standards of quality for fresh and processed use, by developing superior cultivars with greater winterhardiness and disease resistance, and improving management practices.

GOAL 3: VEGETABLES. By 1982, to have developed new information and technology that will make possible a 5% increase in unit yield of vegetable crops, while achieving higher standards of quality for fresh and processed use, by developing superior cultivars and improving management practices.

GOAL 4: POTATOES. By 1982, to have provided new information and technology that will make possible a 5% increase in unit yield of potatoes, while achieving higher standards of quality for fresh and processed use, by developing superior cultivars and improving pest control and management practices.

GOAL 5: ORNAMENTALS. By 1982, to have developed and introduced 12 new and improved cultivars of greenhouse crops, nursery stock, and turf grasses that are needed by the ornamentals trades; to have achieved a 5% increase in the yield of commercial ornamental crops, by improving cultural practices; and to have reduced energy consumption in greenhouses to 15% lower than previous levels.

## **6 Field crops**

To improve the efficiency of production and quality of field crops such as tobacco, field peas, buckwheat, new crops, and field beans.

GOAL 1: TOBACCO. By 1982, to have provided new information and technology that will make possible a better understanding of tobacco quality and make possible a 10% increase in unit yield of tobaccos improved to meet market demand, by developing superior cultivars, improving management practices, and applying knowledge of tobacco quality characteristics.

GOAL 2: FIELD PEAS. By 1981, to have provided new information and technology that will make possible a 5% increase in unit yield of field peas, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management practices.

GOAL 3: BUCKWHEAT. By 1982, to have provided new information and technology that will make possible a 5% increase in unit yield of buckwheat, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management practices.

GOAL 4: NEW CROPS. By 1982, to have determined the potential and suitability for commercial production of 10 selected new crops, through assessment of their production and market aspects, and to have demonstrated the method of growing, protecting, and utilizing 5 new crops previously identified as having this potential.

GOAL 5: FIELD BEANS. By 1979, to have provided new information and technology that will make possible a 5% increase in unit yield of field beans, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management and post-harvest storage practices.

## **PRODUCTION SUPPORT**

### **1 Supportive research and development**

To provide new research information on crops, animals, and soils.

GOAL 1: WINTERHARDINESS. By 1980, to have defined and described selected physiological activities in plants, by completing biochemical and physiological studies, and to have shown how these properties can be used to improve efficiency of crop production.

GOAL 2: NITROGEN FIXATION. By 1979, to have developed information on new or more effective ways of fixing atmospheric nitrogen, by studying hosts, bacteria, and the biological processes.

GOAL 3: CYTOGENETICS. To develop methods of producing doubled haploids for breeding cereal and crucifer species; to establish cell and protoplast cultures for more efficient selection of useful mutants, for parasexual hybridization, and for whole-plant regeneration in several crop species; and to analyze cytogenetic relationships that facilitate interspecific transfer of genes in cereal and brome grass species.

GOAL 4: RESEARCH SERVICES. On a continuing basis, to maintain a Canadian collection of plant gene resources and a storage and retrieval system for gene data; to produce and distribute special

seed for plant breeders; and to provide research and service in electron microscopy and analytical chemistry.

GOAL 5: ENGINEERING AND STATISTICS. On a continuing basis, to support branch and departmental research and development, by providing services in statistical design, analysis, and interpretation, and by developing instruments, apparatus, and equipment.

## **2 Protection support**

To provide new general research information on the protection of crops from diseases, insects, and weeds.

GOAL 1: BIOLOGICAL CONTROL OF WEEDS. By 1982, to have developed new information and technology for determining the potential for biological control of 25 major weeds, by selecting, establishing, and assessing suitable biotic agents.

GOAL 2: INTEGRATED CONTROL OF INSECT PESTS IN RAPESEED CROPS. By 1982, to have provided new information and technology that will make possible the development of one or more management systems for controlling insect pests in rapeseed crops, by studying insects and their natural control factors, and evaluating the benefit-to-cost and benefit-to-risk relationships and the impact of control procedures on environmental quality.

GOAL 3: DISEASE AND INSECT CONTROL. By 1982, to have achieved a better understanding of the mode of action, degradation, and side effects of selected insecticides and fungicides, and to have improved the control of injurious insects and fungal diseases with the use of chemical pesticides and with the development of more effective chemical agents.

GOAL 4: CONTROL OF PLANT VIRUSES AND MYCOPLASMS. By 1982, to have improved control of plant viruses and mycoplasmas, by developing further information on their biochemistry and ultrastructure, their vector-host relationships, and their mechanisms of movement and infection in plants.

GOAL 5: CONTROL OF NEMATODE DISEASES. By 1982, to have improved control of nematode diseases, by identifying the species on major agricultural crops, studying their host-parasite relationships, and improving the effectiveness of nematocide use in integrated control systems.

GOAL 6: WEED CONTROL WITH HERBICIDES. By 1982, to have developed environmentally safe and effective methods for controlling selected weeds with herbicides, by studying their mode of action, methods of application, and persistence in the environment.

GOAL 7: WEED ECOLOGY. By 1981, to have provided technological information that will make it possible to reduce crop losses caused by weeds, by studying the ecology of 30 selected weeds and gathering information on their biological importance, interaction with other plant species, life cycles, reactions to herbicides and cultural management practices, and other biological characteristics.

## **3 Biosystematics**

To clarify the taxonomy of and provide identification services for vascular plants, insects, arachnids, nematodes, and fungi found in Canada.

GOAL 1: VASCULAR PLANTS. By 1980, to have resolved the taxonomy of selected groups of vascular plants, particularly those relating to Canadian agriculture, by completing floristic surveys and inventories of selected areas, developing and maintaining a National Vascular Plant Herbarium and a collection of living plants, and providing an efficient identification and information service.

GOAL 2: INSECTS, ARACHNIDS, AND NEMATODES. By 1980, to have completed the taxonomy of selected groups of insects, arachnids, and nematodes, particularly those relating to Canadian agriculture, by making faunal surveys and inventories of selected areas, developing and maintaining a national collection of these biota, and providing an efficient identification and information service.

GOAL 3: FUNGI. By 1980, to have improved the taxonomy of selected groups of fungi, particularly those relating to Canadian agriculture, by completing fungal surveys and inventories of selected areas, developing and maintaining a National Herbarium and Culture Collection, and providing an efficient identification and information service.

## **FARM INPUT SUPPLY**

### **1 Machinery and structures**

To provide information and technology needed for improving and better utilizing farm structures and machinery.

GOAL 1: MACHINERY AND STRUCTURES TECHNOLOGY. On a continuing basis, to support branch and departmental programs on farm machinery and structures, by providing, developing, and assessing new and existing technology.

## PROCESSING

### 1 Processing technology

To develop new food processing technology and to improve the efficiency and effectiveness of food processing systems, including background research on the chemical and physical changes that take place during processing, and evaluation at a pilot-plant scale, as required.

GOAL 1: FOOD PROCESSING. By 1982, to have developed or improved technology and equipment for extracting and utilizing components of selected plant and animal agricultural products and converting fresh material into attractive and stable processed foods.

GOAL 2: FOOD QUALITY. By 1982, to have developed new or improved technology for measuring and improving the quality of selected food products at intermediate and final stages of processing, and to have improved food quality in the finished product, by studying the reactions that take place during processing.

### 2 New-product development

To develop and characterize useful new ingredients or products for presentation to private industry for evaluation and application, and to develop the technology required to produce them, including evaluation at a pilot-plant scale, as required.

GOAL 1: NEW INGREDIENTS. By 1982, to have developed methods and processes of interest to industry for new food ingredients with valuable functional or nutritional properties.

GOAL 2: NEW FOODS. By 1982, to have developed methods and processes of interest to industry for new food products with commercial potential.

## DISTRIBUTING

### 1 Stored products

To improve the technology and effectiveness of off-farm storage of fresh fruits and vegetables, and to reduce losses in stored grains and oilseeds by controlling insects.

GOAL 1: STORAGE OF FRUITS AND VEGETABLES. By 1982, to have developed new information and technology that will make possible a 10% extension of the storage life of fresh fruits and vegetables, while maintaining or improving product quality, through physiological studies and the development of optimum storage conditions.

GOAL 2: STORAGE OF GRAINS AND OILSEEDS. By 1982, to have developed methods and provided recommendations that will make possible a 10% reduction in losses caused by infestation of insects, mites, and fungi in cereals, oilseeds, and their products during storage, by conducting surveys of pest populations and research on control measures.

## FOOD SAFETY AND NUTRITION

### 1 Food safety

To increase consumer protection by conducting research to reduce antinutritional factors and microbiological and chemical contaminants in agricultural products and foods.

GOAL 1: TOXICANTS AND CONTAMINANTS. By 1982, to have defined potential hazards caused by selected undesirable material in feedstuffs and foods (pathogenic organisms, mycotoxins, heavy metals, pesticide residues, and selected food additives), by studying their occurrence and their interactions in the food system, and to have developed control procedures to prevent their occurrence or remove them.

### 2 Nutrition

To assist in improving the general level of nutrition of Canadian consumers.

GOAL 1: FOOD COMPOSITION AND NUTRIENT AVAILABILITY. By 1982, to have provided new information and technology that will make it possible to improve nutrition, by breeding crops and animals, monitoring the composition of animal and plant material, formulating food products derived from them, and determining the availability of selected nutrients.



# STRUCTURE DU PROGRAMME DE LA DIRECTION DE LA RECHERCHE

## Objectif du Ministère

L'objectif fondamental du ministère de l'Agriculture du Canada, dans le cadre de l'ensemble des objectifs gouvernementaux et en collaboration avec les gouvernements provinciaux, est de développer le réseau agro-alimentaire canadien et de l'aider à répondre aux besoins des marchés national et étrangers et à remplir ses engagements en matière d'aide internationale de manière à assurer: (a) aux consommateurs, un approvisionnement sûr d'aliments sains et nutritifs à prix raisonnable et (b) aux producteurs et aux transformateurs, une rémunération équitable.

## Objectifs et buts de la Direction

### TERRE

#### 1 Gestion et conservation des sols

Trouver les principales causes qui nuisent à la productivité de certains sols.

BUT 1: PROBLÈMES PÉDOLOGIQUES. D'ici 1982, chercher de nouveaux moyens d'améliorer la pratique de sols sélectionnés, par l'étude de leurs caractéristiques chimiques, biologiques et physiques.

#### 2 Utilisation et ressources des terres

Constituer un inventaire complet des sols canadiens et améliorer des méthodes pour mieux les caractériser, les classer et les évaluer.

BUT 1: PROSPECTION ET CLASSIFICATION DES SOLS. D'ici 1980, rendre possible une meilleure utilisation des ressources pédologiques dans certaines régions du Canada en constituant un inventaire et en établissant des méthodes et des critères plus efficaces de classification et de cartographie des sols.

BUT 2: ÉVALUATION DES TERRES. D'ici 1982, élaborer des méthodes d'évaluation des ressources pédologiques canadiennes pour la production agricole.

### EAU

#### 1 Irrigation, drainage et dessalinisation

Améliorer les techniques d'utilisation des ressources hydriques, l'irrigation et le drainage des sols canadiens dans le but d'en améliorer la productivité.

BUT 1: IRRIGATION, DRAINAGE ET DESSALINISATION. D'ici 1982, augmenter le potentiel de production de sols sélectionnés en accroissant l'efficacité de l'utilisation des ressources hydriques et en mettant au point de meilleures méthodes d'irrigation, de drainage et de dessalinisation.

#### 2 Indices météorologiques et climatologiques

Accroître l'utilisation des données météorologiques.

BUT 1: INDICES MÉTÉOROLOGIQUES ET CLIMATOLOGIQUES. D'ici 1980, accroître l'utilisation de l'information climatologique, particulièrement en ce qui a trait aux opérations agricoles tributaires du climat, au chapitre des prévisions sur la productivité et dans le domaine de l'application des recherches, grâce à l'amélioration des méthodes, l'évaluation et l'interprétation des données disponibles obtenues à la suite d'une sélection d'indices météorologiques et climatologiques.

### ÉNERGIE ET QUALITÉ DE L'ENVIRONNEMENT

#### 1 Énergie

Améliorer la production, l'utilisation et la conservation de l'énergie sur l'exploitation.

BUT 1: UTILISATION ET CONSERVATION DE L'ÉNERGIE. D'ici 1982, atténuer la dépendance de l'agriculteur envers les combustibles fossiles et réduire les coûts de l'énergie utilisée dans la production par l'application des techniques actuelles et par le développement et l'application de techniques nouvelles.

#### 2 Qualité de l'environnement

Élaborer des pratiques de gestion agricole correspondant à la production et respectant l'environnement.

**BUT 1 RÉSIDUS ET ÉLÉMENTS NUTRITIFS VÉGÉTAUX.** D'ici 1982, grâce à des études sur le terrain et en laboratoire ainsi qu'à la mise au point et à l'évaluation du matériel nécessaire à cette fin, mettre au point des données et des techniques nouvelles de contrôle de la pollution causée par les éléments nutritifs végétaux et les résidus de divers systèmes de production animale et végétale.

**BUT 2 UTILISATION DES PESTICIDES.** D'ici 1980, déterminer les critères économiques et l'acceptabilité pour l'environnement des systèmes actuels et futurs d'utilisation des pesticides, par l'emploi de modèles, par des études sur les pesticides et leurs résidus dans le sol ainsi que par l'élaboration et l'amélioration des méthodes et du matériel utilisés.

## **PRODUCTION AGRO-ALIMENTAIRE (ANIMAUX)**

### **1 Bovins de boucherie**

Accroître l'efficacité de la production bovine et améliorer la qualité des produits.

**BUT 1 SÉLECTION ET CROISEMENT.** D'ici 1982, mettre au point de nouvelles données qui permettront d'accroître de 5% les rendements en viande par vache reproductrice, tout en maintenant ou en améliorant la qualité des carcasses et de la viande, grâce à la mise en oeuvre d'un programme de sélection et de croisement.

**BUT 2: SYSTÈME D'ÉLEVAGE VACHE-VEAU.** D'ici 1982, mettre au point de nouvelles données qui permettront d'accroître de 7% la production de veaux par vache et de 25% celle de veaux par hectare, grâce à des recherches multidisciplinaires sur les systèmes d'élevage vache-veau, les prairies, les cultures fourragères et les déchets des cultures.

**BUT 3: PARCS D'ENGRASSEMENT.** D'ici 1982, développer des systèmes plus économiques d'alimentation et de conduite des troupeaux, améliorer les méthodes de transformation et d'utilisation des sous-produits et des déchets de culture comme aliments, adopter des mesures préventives contre les troubles et les déficiences métaboliques et améliorer le contrôle de la composition des carcasses.

**BUT 4: INSECTES NUISIBLES.** D'ici 1983, mettre au point des méthodes pour mesurer le niveau de parasitisme chez les ruminants; définir les interactions hôte-parasite régissant les populations parasites des mouches sauvages hémophages dans l'environnement des bovins et de l'homme et élucider le rôle des populations de moustiques, de leur comportement et des moyens de lutte dans l'étiologie du virus de l'encéphalite.

### **2 Bovins laitiers**

Accroître l'efficacité de la production laitière.

**BUT 1: REPRODUCTION, GÉNÉTIQUE ET CONDUITE DES TROUPEAUX.** D'ici 1980, mettre au point des données qui permettront d'accroître de 10% l'efficacité globale de la production laitière grâce à des techniques de croisement et des systèmes de production intensive.

**BUT 2: NUTRITION ET GESTION DE LA PRODUCTION LAITIÈRE.** D'ici 1981, mettre au point des techniques améliorées et des données nouvelles permettant l'utilisation optimale des aliments dans la production laitière en fonction des diverses conditions géographiques et économiques.

### **3 Porcs**

Accroître l'efficacité de la production porcine et améliorer la qualité de la viande et des produits du porc.

**BUT 1: PORCS.** D'ici 1981, mettre au point de nouvelles données qui permettront d'accroître de 5% le rendement de porc par unité d'énergie alimentaire tout en améliorant la qualité de la viande par des recherches sur l'amélioration génétique, la physiologie de la reproduction et la mise au point de meilleurs systèmes d'alimentation et de gestion.

### **4 Volailles**

Accroître l'efficacité de la production des oeufs et améliorer la qualité des produits.

**BUT 1: VOLAILLES.** D'ici 1982, mettre au point de nouvelles données sur l'amélioration génétique, l'alimentation et la conduite des pondeuses qui permettront d'accroître de 4% le poids des oeufs et de 10% la production de viande par unité d'énergie alimentaire, en plus de mettre au point de nouvelles données sur les facteurs déterminants de la qualité intérieure de l'oeuf et de sa coquille, par la reproduction et la sélection, et aussi par la diminution des troubles du métabolisme et la mise au point de meilleurs systèmes d'alimentation et de conduite des troupeaux.

### **5 Moutons**

Améliorer l'efficacité de l'élevage ovin et la qualité des produits du mouton et de l'agneau.

**BUT 1: MOUTONS.** D'ici 1982, grâce à l'amélioration des races et à l'efficacité de la reproduction ainsi qu'à l'élaboration de meilleurs systèmes d'alimentation et de conduite des troupeaux, mettre au

point de nouvelles données qui permettront d'accroître de 15% la production d'agneau par brebis et de 5% le taux de croissance des agneaux.

## **6 Abeilles et autres animaux**

Accroître l'efficacité de la production des abeilles et des autres animaux et améliorer la qualité de leurs produits.

**BUT 1 - ABEILLES.** D'ici 1982, mettre au point de nouvelles données qui permettront d'accroître de 2% la productivité des abeilles, grâce à des recherches sur les phéromones, à la réduction de l'incidence des maladies et à l'amélioration de la conduite des ruchers.

**BUT 2: ANIMAUX À FOURRURE.** D'ici 1979, accroître de 5% la production d'animaux à fourrure en améliorant les systèmes d'alimentation et l'efficacité de la reproduction et en réduisant l'incidence des maladies. (Recherches extra-muros seulement)

## **DÉVELOPPEMENT DE LA PRODUCTION (CULTURES)**

### **1 Blé**

Poursuivre des recherches multidisciplinaires pour améliorer la production, la protection et l'utilisation du blé canadien.

**BUT 1: BLÉ.** D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 10% le rendement unitaire des blés durs, d'hiver et de printemps, tout en maintenant la qualité de chaque culture pour répondre aux besoins du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

### **2 Autres cultures céréalières**

Poursuivre des recherches multidisciplinaires pour améliorer la production, la protection et l'utilisation des autres cultures céréalières du Canada.

**BUT 1: ORGE.** D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire d'orge, tout en maintenant la qualité pour satisfaire la demande du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

**BUT 2: AVOINE.** D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire de l'avoine, tout en maintenant la qualité pour répondre aux besoins du marché, par la création de variétés supérieures et l'amélioration des pratiques culturales.

**BUT 3: MAÏS.** D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 10% le rendement unitaire du maïs-grain ou du maïs d'ensilage, tout en maintenant la qualité pour satisfaire la demande du marché, ou accroître de 1% la superficie cultivée de maïs, grâce à la création de variétés autofécondées supérieures et d'hybrides supérieurs de maïs-grain et de maïs d'ensilage et à l'amélioration des pratiques culturales.

**BUT 4: SEIGLE.** D'ici 1982, mettre au point des données et des techniques nouvelles qui permettront d'accroître de 10% le rendement unitaire du seigle d'hiver, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

### **3 Oléagineux**

Mener des recherches multidisciplinaires pour améliorer l'efficacité de la production, l'adaptabilité et la qualité des oléagineux et de leurs produits.

**BUT 1: COLZA ET MOUTARDE.** D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 3% le rendement unitaire du colza et de la moutarde et d'améliorer la qualité de la graine et de ses produits pour répondre aux besoins du marché, grâce à la création de variétés supérieures, à l'amélioration des pratiques culturales et à des recherches axées sur l'utilisation du produit.

**BUT 2: TOURNESOL.** D'ici 1982, mettre au point des données et des techniques nouvelles qui permettront d'accroître de 10% le rendement unitaire des graines de tournesol dans les zones de sol noir et la production de graines de tournesol dans les zones de sol brun, tout en maintenant ou en améliorant la qualité de la graine et de ses produits pour répondre à la demande des marchés, par la création de variétés autofécondées supérieures et d'hybrides supérieurs et l'amélioration des pratiques culturales.

**BUT 3: SOJA.** D'ici 1979, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire du soja et de déterminer sa valeur comme culture possible dans de nouvelles régions, tout en maintenant ou en améliorant sa qualité pour répondre aux besoins du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

**BUT 4: LIN.** D'ici 1982, mettre au point des données et des techniques nouvelles permettant

d'accroître de 5% le rendement unitaire du lin, tout en conservant ou en améliorant la qualité pour répondre aux besoins du marché, par la création de variétés supérieures et l'amélioration des pratiques culturales.

#### **4 Cultures fourragères**

Poursuivre des recherches multidisciplinaires pour augmenter l'efficacité des systèmes de production de cultures fourragères ainsi que la qualité de ces dernières.

**BUT 1: LÉGUMINEUSES.** D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 10% le rendement unitaire en matière sèche digestible des légumineuses, grâce à l'amélioration des pratiques culturales, à la création de variétés supérieures et à l'accroissement de la production de semences.

**BUT 2: GRAMINÉES.** D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 10% le rendement unitaire en matière sèche digestible des graminées, grâce à l'amélioration de pratiques culturales, à la création de variétés supérieures et à l'accroissement de la production de semences.

#### **5 Horticulture**

Améliorer, par le biais de la recherche multidisciplinaire, l'efficacité de la production et de la qualité des cultures horticoles.

**BUT 1: FRUITS DE VERGER.** D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 10% le rendement unitaire des fruits de verger, tout en maintenant ou en améliorant les normes de qualité des produits frais et transformés, grâce à la création de meilleurs cultivars et à l'amélioration des pratiques culturales.

**BUT 2: PETITS FRUITS.** D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement des petits fruits, tout en respectant des normes plus élevées de qualité des produits frais et transformés, grâce à la création de cultivars supérieurs résistant mieux au froid et à la maladie et grâce à l'amélioration des pratiques culturales.

**BUT 3: LÉGUMES.** D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'augmenter de 5% le rendement unitaire des légumes, tout en respectant des normes plus élevées de qualité des produits frais et transformés, grâce à la création de meilleurs cultivars et à l'amélioration des pratiques culturales.

**BUT 4: POMMES DE TERRE.** D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire des pommes de terre, tout en respectant des normes plus élevées de qualité des produits frais et transformés, grâce à la création de meilleurs cultivars et de meilleurs moyens de lutte contre les ravageurs et à l'amélioration des pratiques culturales.

**BUT 5: PLANTES ORNEMENTALES.** D'ici 1982, créer et introduire 12 nouveaux cultivars améliorés de plantes de serre, de pépinière et de graminées à gazon correspondant à la demande de ce marché; accroître de 5% la productivité du secteur commercial des plantes ornementales par l'amélioration des pratiques culturales; enfin, réduire de 15% la consommation d'énergie dans les serres.

#### **6 Grandes cultures**

Améliorer l'efficacité de la production et la qualité des grandes cultures comme le tabac, les pois, les haricots, le sarrasin et les nouvelles cultures.

**BUT 1: TABAC.** D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'élargir les connaissances sur la qualité des tabacs et d'accroître de 10% le rendement unitaire des variétés de tabac améliorées en vue de répondre à la demande du marché, par la création de meilleurs cultivars, l'amélioration des pratiques culturales et l'application des connaissances acquises dans le domaine de la qualité du tabac.

**BUT 2: POIS DE GRANDE CULTURE.** D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire des pois, tout en maintenant ou en améliorant la qualité pour répondre à la demande du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

**BUT 3: SARRASIN.** D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire du sarrasin, tout en maintenant ou en améliorant la qualité pour répondre à la demande du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

**BUT 4: NOUVELLES CULTURES.** D'ici 1982, déterminer les possibilités d'implantation de 10 nouvelles cultures par l'évaluation des conditions de production et de mise au marché, et mettre au

point les méthodes de production, de protection et d'utilisation de 5 nouvelles cultures dont les possibilités ont déjà été reconnues.

BUT 5: HARICOTS. D'ici 1979, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire des haricots, tout en maintenant ou en améliorant la qualité pour répondre à la demande du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales et des méthodes d'entreposage.

## APPUI À LA PRODUCTION

### 1 Recherches et développements

Fournir de nouvelles données concernant les recherches sur les cultures, les animaux et les sols.

BUT 1: RUSTICITÉ. D'ici 1980, définir et décrire diverses activités physiologiques des végétaux par des études biochimiques et physiologiques et montrer comment ces caractéristiques peuvent être utilisées pour améliorer l'efficacité des productions culturales.

BUT 2: FIXATION DE L'AZOTE. D'ici 1979, mettre au point des données sur les méthodes nouvelles ou améliorées de fixation de l'azote dans l'atmosphère, par l'étude des hôtes, des bactéries et des fonctions biologiques.

BUT 3: CYTOGÉNÉTIQUE. Élaborer des méthodes de production de cultivars diploïdes à partir d'haploïdes, y compris les céréales et les cruciféracées; progresser dans l'établissement de cultures cellulaires et de protoplastes pour une meilleure sélection des mutants en demande, pour la création d'hybrides parasexuels et pour la régénération de plantes entières appartenant à plusieurs espèces culturales; élucider les relations cytogénétiques facilitant le transfert génétique entre diverses espèces de céréales et de luzerne.

BUT 4: SERVICES DE RECHERCHES. Maintenir de façon permanente une collection canadienne des ressources phytogénétiques ainsi qu'une banque et un système de récupération de données génétiques; produire des semences spéciales à l'intention des phytosélectionneurs et assurer leur distribution; assurer un service de microscopie électronique et de recherche chimio-analytique.

BUT 5: GÉNIE ET STATISTIQUE. Appuyer de façon permanente les programmes de recherches et de développements de la Direction et du Ministère par l'élaboration, l'analyse et l'interprétation des statistiques et la conception d'instruments, d'appareils et d'équipement.

### 2 Protection

Mettre au point de nouvelles données de recherches applicables de façon générale à la protection des cultures contre les maladies, les insectes et les mauvaises herbes.

BUT 1: LUTTE BIOLOGIQUE CONTRE LES MAUVAISES HERBES. D'ici 1982, mettre au point des données et des techniques nouvelles permettant de déterminer les possibilités de succès de la lutte biologique contre 25 des plus importantes mauvaises herbes, par la sélection, la création et l'évaluation d'agents biotiques appropriés.

BUT 2: LUTTE INTÉGRÉE CONTRE LES INSECTES DU COLZA. D'ici 1982, mettre au point des données et des techniques nouvelles qui permettront l'élaboration d'un ou de plusieurs systèmes de lutte contre les insectes du colza, en menant des recherches sur ces insectes et leurs prédateurs et en évaluant les rapports coût-bénéfice et risque-bénéfice et l'impact des méthodes de lutte sur la qualité de l'environnement.

BUT 3: MALADIES ET LUTTE CONTRE LES INSECTES. D'ici 1982, élargir les connaissances des modes d'action, de dégradation et des effets secondaires de divers insecticides et fongicides et rendre possible la lutte améliorée contre les insectes dangereux et les maladies fongiques par les pesticides chimiques, tout en développant des agents chimiques plus efficaces.

BUT 4: LUTTE CONTRE LES VIROSES ET LES MYCOPLASMES. D'ici 1982, améliorer les méthodes de lutte contre les virus et les mycoplasmes des végétaux en menant des études plus poussées sur leur biochimie et leur ultrastructure, les rapports vecteur-hôte et les mécanismes de propagation et d'infection.

BUT 5: LUTTE CONTRE LES NÉMATODES. D'ici 1982, améliorer les méthodes de lutte contre les maladies causées par les nématodes en identifiant les espèces qui s'attaquent aux principales cultures, en étudiant les rapports hôte-parasite et en déterminant les méthodes d'utilisation les plus efficaces des nématicides dans la lutte intégrée contre les ravageurs.

BUT 6: LUTTE CONTRE LES MAUVAISES HERBES PAR LES HERBICIDES. D'ici 1982, mettre au point des méthodes de lutte efficaces et non dommageables à l'environnement, capables d'éliminer certaines mauvaises herbes au moyen d'herbicides, grâce à des études sur leur mode d'action, les façons de les appliquer et leur persistance dans l'environnement.

BUT 7: ÉCOLOGIE DES MAUVAISES HERBES. D'ici 1981, mettre au point des données et des

techniques nouvelles permettant de réduire les pertes de récoltes causées par les mauvaises herbes, grâce à l'étude écologique de 30 mauvaises herbes sélectionnées et à la collecte de données sur leur importance biologique, sur leur interaction avec d'autres espèces végétales, sur leur cycle vital, sur leur réaction aux herbicides et aux pratiques culturales et sur leurs autres caractéristiques biologiques.

### **3 Biosystématique**

Clarifier la taxonomie et assurer un service efficace d'identification des plantes vasculaires, des insectes, des arachnides, des nématodes et des champignons du Canada.

**BUT 1 PLANTES VASCULAIRES.** D'ici 1980, résoudre les problèmes relatifs à la taxonomie de groupes sélectionnés de plantes vasculaires, en particulier celles qui intéressent le secteur agricole canadien, en effectuant des relevés floristiques et en constituant des répertoires de la flore pour les régions choisies, en montant et en conservant un herbier de plantes vasculaires ainsi qu'une collection de plantes vivantes et en fournissant, à partir de ces travaux, un service efficace d'information et d'identification.

**BUT 2. INSECTES, ARACHNIDES ET NÉMATODES.** D'ici 1980, compléter la taxonomie de groupes sélectionnés d'insectes, d'arachnides et de nématodes, particulièrement ceux qui intéressent le secteur agricole canadien, en effectuant des relevés de la faune, en dressant des répertoires pour les régions choisies, en montant et en conservant une collection nationale de ces biotes et en fournissant, à partir de ces travaux, un service efficace d'identification et d'information.

**BUT 3: CHAMPIGNONS.** D'ici 1980, améliorer la taxonomie de groupes sélectionnés de champignons, surtout ceux qui intéressent le secteur agricole canadien, en effectuant des relevés mycologiques et en constituant des répertoires des champignons pour les régions choisies, en montant et en conservant un herbier national et une collection des cultures de champignons et en fournissant, à partir de ces travaux, un service efficace d'identification et d'information.

## **FACTEURS DE PRODUCTION AGRICOLE**

### **1 Machinerie et structures**

Mettre au point des données et des techniques nécessaires à l'amélioration et à une meilleure utilisation des structures et de la machinerie agricoles.

**BUT 1 TECHNOLOGIE DE LA MACHINERIE ET DES STRUCTURES.** Appuyer de façon permanente les programmes de la Direction et du Ministère concernant la machinerie et les structures agricoles en fournissant, développant et évaluant les techniques courantes et nouvelles.

## **TRANSFORMATION**

### **1 Technologie de la transformation**

Élaborer de nouvelles techniques de transformation alimentaire et améliorer l'efficacité des systèmes de transformation, en favorisant la recherche de base sur les modifications chimiques et physiques que subissent les aliments au cours de la transformation ainsi que l'évaluation à l'échelle des établissements, le cas échéant.

**BUT 1: TRANSFORMATION ALIMENTAIRE.** D'ici 1982, mettre au point ou améliorer des techniques et de l'équipement afin d'extraire et d'utiliser des composantes de produits agricoles sélectionnés, d'origine végétale ou animale, et afin de convertir des produits frais en aliments transformés qui se conservent bien et ont une apparence savoureuse.

**BUT 2: QUALITÉ DES ALIMENTS.** D'ici 1982, mettre au point des techniques nouvelles ou perfectionnées de mesures et d'amélioration de la qualité de divers produits alimentaires sélectionnés au niveau intermédiaire et final de leur transformation et rehausser la qualité des produits alimentaires finis par une meilleure connaissance des réactions qui surviennent au cours de la transformation.

### **2 Développement de nouveaux produits**

Mettre au point et caractériser des ingrédients ou produits nouveaux et utiles en vue de les soumettre au secteur privé pour évaluation et fabrication, et mettre au point également la technologie nécessaire à leur production, y compris leur évaluation par des projets-pilotes, le cas échéant.

**BUT 1: NOUVEAUX INGRÉDIENTS.** D'ici 1982, mettre au point des méthodes et des procédés intéressant le secteur chargé de trouver de nouveaux ingrédients alimentaires qui pourraient offrir des propriétés fonctionnelles et nutritionnelles valables.

**BUT 2 NOUVEAUX ALIMENTS.** D'ici 1982, mettre au point des méthodes et des procédés qui permettront aux secteurs intéressés de développer de nouveaux produits alimentaires commercialisables.

## DISTRIBUTION

### 1 Produits entreposés

Améliorer les techniques et l'efficacité de l'entreposage des fruits et des légumes frais hors des exploitations; dans les entrepôts, réduire les pertes de céréales et d'oléagineux par une lutte soutenue contre les insectes.

BUT 1: ENTREPOSAGE DES FRUITS ET DES LÉGUMES. D'ici 1982, mettre au point des données et des techniques nouvelles qui permettront une prolongation de 10% de la conservation en entrepôt des fruits et légumes frais, tout en maintenant ou en améliorant leur qualité, grâce à des études physiologiques et à l'élaboration de meilleures conditions d'entreposage.

BUT 2: ENTREPOSAGE DES CÉRÉALES ET DES OLÉAGINEUX. D'ici 1982, élaborer des méthodes et faire les recommandations permettant de réduire de 10% les pertes que causent les insectes, les acariens et les champignons aux céréales, aux oléagineux et à leurs produits en entreposage, grâce à des études sur les populations de parasites et des recherches sur les moyens de lutte.

## SALUBRITÉ DES ALIMENTS ET NUTRITION

### 1 Salubrité

Augmenter la protection du consommateur par des recherches visant à diminuer les facteurs antinutritionnels et les contaminants microbiologiques et chimiques dans les produits agricoles et les aliments.

BUT 1: PRODUITS TOXIQUES ET CONTAMINANTS. D'ici 1982, définir les dangers possibles de divers produits indésirables que renferment les aliments de consommation animale et humaine (organismes pathogènes, mycotoxines, métaux lourds, résidus d'antiparasitaires et additifs alimentaires divers), grâce à des recherches sur leur taux dans les aliments et leur interaction sur le circuit alimentaire, et élaborer des méthodes de contrôle pour leur prévention ou leur retrait.

### 2 Nutrition

Contribuer à l'amélioration du régime alimentaire général du consommateur canadien.

BUT 1: COMPOSITION ET VALEUR NUTRITIVE DES ALIMENTS. D'ici 1982, mettre au point des données et des techniques nouvelles permettant de rehausser la valeur nutritive des aliments par l'amélioration végétale et animale, par le contrôle de la composition des sources alimentaires animales et végétales, par la formulation des produits alimentaires qui en sont dérivés et par l'évaluation de la disponibilité de divers éléments nutritifs dans les aliments.











